THE ROLE OF HOUSEHOLD PESTS IN THE EPIDEMIOLOGICAL TRANSITION OF ALLERGY: MODERNIZATION OF THE DOMESTIC ENVIRONMENT IN BARBADOS

By

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This thesis is dedicated to the children of Barbados.

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Allergy is referred to as part of the epidemiological transition of disease; it is uncommon in traditional societies, is steadily increasing in developed societies, and demonstrates dramatic incidences in transitional societies. Some of the most antigenic allergens are from arthropods (arboallergens). Pan allergy to insects and noninsect arthropods has been exhibited in individuals who have previously been sensitized to only a few arboallergens.

Previous research demonstrated that _D. pteronyssinus_ (_Dp_) was the predominant house dust mite (HDM) in Barbados and that wood homes on rock foundations provided an ideal mite habitat. The contemporary trend is an integration of permanent features into the traditional house form (e.g., concrete and indoor plumbing into the traditional house form); this trend is a

metaphor for sociocultural change because of the historically tenuous nature of land tenure and housing in Barbados. Concrete, plumbing, and other "modern" features have been incriminated in increasing indoor relative humidity and reducing air flow, two factors which create favorable habitats for a number of household pests.

Asthma is increasing in Barbados; asthmatic attacks reported to the Casualty Clinic doubled in 10 years to 7,137 in 1990. The current study was undertaken to examine the effects of contemporary housing on the distribution of household pests and the harmful effects that exposure to arboallergens might have on the asthmatic. Densities of Dp were found in 100% of homes sampled and were higher in concrete homes ($f=9.55$, $p<0.001$); qualitative data suggest that other pests prevail in both types of construction. Asthmatic children (168) were skin tested against 11 household pest allergens; HDM elicited the greatest number of responses (77.4% to Dp and 74.4% to D. farinae, or Df). Allergy to Dp was correlated to living in a concrete home ($X^2=4.37$, $p=0.04$). The high incidence of allergy to Df despite low or absent densities and a positive reaction to an average of four different pests suggest cross-reactivity. The implications of the study are the following: housing trends have a direct influence on the presence of Dp, a highly allergenic pest; and sensitivity to Dp possibly predisposes asthmatics to develop other arboallergen hypersensitivities, thus increasing the likelihood of morbidity related to arboallergens.

CHAPTER 1
ALLERGY AS A DISEASE OF MODERNIZATION

Introduction: Rationale for the Study

The Relationship Between Modernization and Allergy

As humans have evolved culturally, we have increasingly exposed ourselves to numerous pathogens due to our alterations in the environment, complex food-producing practices, and intense contact with other infected humans and their waste products (for many populations this picture remains the same today, although the sociopolitical reasons have changed with time). The bulk of these pathogens in earlier agriculturalist populations were those responsible for infectious disease, usually vector-borne and parasitic and not dependent on large populations or even human hosts for their survival. With the development of industrial societies, cultural advances in technology enhanced the provision of better sanitary practices (e.g., systems for waste disposal, treated water), which eliminated a number of the parasitic diseases, and biomedical advances provided chemotherapy and immunization against many of the debilitating and mortal communicable diseases. As a result, large numbers of people living in what are considered "developed" countries have never even been exposed to a

parasite or to many of the viruses and bacteria that eliminated whole societies. This process has resulted in what has been termed the "epidemiological transition" of disease, defined as a trend from acute infectious diseases to chronic noninfectious disease and generally industrial and degenerative in nature (Omran 1971; Corruccini and Kaul 1983). The increasing prevalence of these diseases is related to human modernization and urbanization.

Extreme changes in contemporary modes of production have resulted in the introduction of new organic and inorganic substances in the contemporary macroenvironment. These substances are inhaled and ingested both at home and at the work place, or the microenvironment. There is extreme class consciousness, as well as continuous efforts to "move up" socially and "improve" the home environment with the addition of non-consumable goods and climate control. The net result of these cultural changes is exposure to large amounts of substances never before encountered in human history and, more importantly, subjection to these substances in a very short period of time.

One of the new chronic diseases resulting from the epidemiological transition is allergy. Although we do not know the degree of prevalence of allergy in previous populations, we do know that the incidence of allergy is on the rise (Corruccini & Kaul 1983; Massicot & Cohen 1986;

National Asthma Education Program 1991). Contributing to this is exposure to many antigens that, for reasons not completely understood, are highly allergenic. The most common of these are pollens, molds, and notably, arthropods (Gergen et al. 1987). Schwartz (1990) argues that arthropods are more important as allergens than are pollens because they are so widespread.

The Role of Household Pests

Possibly the most significant impact in regard to allergic disease as a result of modernizing our microenvironment has been the increased exposure to peri-domestic and domestic arthropods and rodents. In elaborating the home environment for the purpose of removing ourselves from climatic elements, we have provided ideal habitats for a number of "pests." This is most evident in the study of urban entomology; household infestations of most pests increase with the degree of urbanization (Aedes spp. mosquitoes, Gratz 1973, Slosek 1986; cockroaches, Ebeling 1975, Koehler et al. 1987; rodents, McNeill 1976). What is most alarming about the relationship between urbanization and household pest infestations is the extreme allergenicity of arthropods and certain other animals.

The relationship between an increase in the incidence of allergy in general and modernization has been largely attributed to the development of housing conditions that are favorable to house dust mites (Massicot & Cohen 1986). In

fact, the most predominant allergen among residents in developed and developing countries alike is the house dust mite (Buchanan & Jones 1972; Kang & Sulit 1978; Dowse et al. 1985; Massicot & Cohen 1986; National Asthma Education Program 1991). Dowse et al. (1985) studied the incidence of asthma in eight South Fore villages in the Eastern Highlands of Papua New Guinea. There had been an alarming increase in prevalence over a 10-year period; the overall rate was 39 and 46 times higher than rates noted in 1972 and 1975, respectively, and was much higher than rates reported from other highland regions. The reason was attributed to the introduction of woolen blankets into the villages; <u>Dermatophagoides</u> <u>pteronyssinus</u> and <u>D.</u> <u>farinae</u> were found in 97% of the blankets used by the Fore (Dowse et al. 1985). Baldo and Panzani (1988) suggest that "pan allergy" to insects may exist in individuals who have previously been sensitized to one or several insects and that allergenic similarities possibly extend to other noninsect arthropods, such as spiders or crustaceans. The ramifications of this finding are frightening from an epidemiological point of view when one considers the widespread distribution of arthropods, and the consumption of many of those arthropods (e.g., shrimp, lobster). It implies that any household pest is a potential source of allergen.

Numerous studies have been published that confirm the relationship between cockroach allergens and bronchial

asthma (Kang 1976; Kang & Sulit 1978; Kang & Chang 1985; Kang 1990). Individuals of lower socioeconomic status within the United States reportedly have higher incidences of cockroach hypersensitivity compared to individuals of higher socioeconomic status (Bernton & Brown 1967; Kang & Chang 1985). Authors conclude that this likely is correlated to higher cockroach infestations in poor housing and related to the duration of exposure (Bernton & Brown 1967; Twarog et al. 1977). However, the reverse is true in developing countries (Marchand 1966; Brenner et al. 1990; Brenner et al. 1991). In Puerto Rico, Marchand found that his patients who demonstrated hypersensitivity to cockroaches were from the middle to upper socioeconomic strata (1966). In the Dominican Republic, the incidence of allergy to cockroaches was proportionately related to the quality of the house structure (X^2=7.36, df=2, $p<<0.01$); individuals from higher quality homes had a greater incidence of allergy to cockroaches (Brenner et al. 1990; Brenner et al. 1991). Data suggested that the higher quality homes built of masonry had less air flow than the homes of wood, thereby producing a more favorable environment for the cockroach and also an accumulation of arboallergens.[1] More favorable environments and larger populations also may increase the likelihood of physical contact with cockroaches, resulting in an injectant or ingestant contact with the allergen; cockroach "biting" was

reported in heavily infested, urban environments in both North Central Florida and the Dominican Republic (Barnes & Brenner, in prep.).

In another study, a relationship was found between the presence of house dust mites and the structure of houses. Pearson and Cunnington (1973) identified 23 species of house dust mites in Barbados (*D. pteronyssinus* was the most predominant) and concluded that they were so proliferative because of the timber dwellings situated on top of porous coral rock foundations, which, close to the soil, generated a sufficient amount of moisture to provide excellent habitats for the house dust mites.

Objectives of the Study

Based on the concept that allergy is a disease of modernization and arboallergens as well as other pest allergens (e.g., rodents) play a significant role in the incidence of allergy, a study was designed to test the hypothesis that modernization of the domestic environment is related to allergy to household pests. The domestic environment was chosen as the focal domain because two of the best-known producers of arboallergens--the house dust mite and the cockroach--are domestic pests. Certainly the most concentrated human exposure to arthropods is indoors rather than outdoors.

As with most other diseases that are part of the epidemiological transition, there is a strong genetic

component in the development of allergy. Although people do not have control over their genetic make-up, they do have control over their behavior and to a limited degree, control over their environment. Behaviors and the environment over which the lay person probably has the most control are those related to the home. Because "household pests," as the definition connotes, thrive within the domestic domain, certain sociodemographic variables related to the home likely play a role in both household pest infestations and allergy to pests. If such variables can be controlled by the people living in the affected environment, then residents might be able to play a central role in their own promotion of health and well-being.

Herein lies the guiding research question: What existing human perceptions, behaviors, and household environmental factors contribute to the notion that allergy is a disease of modernization? Specifically, are household pest infestations influenced by modernization of the home, and to what degree do they contribute to allergy? From an immunological perspective, it is suspected that the relationship might be due to the likelihood and degree of exposure to certain household pest species. Exposure to household pest allergens primarily is dependent on two factors: first, there must be a substantial population of the pest for it to produce allergens (most typically aeroallergens); and second, the domestic environment must be

conducive to the maintenance of the pest population and/or the accumulation of the attendant allergens. It is apparent that modernization of specific features of the home increases the degree of pest infestations indirectly, by providing a suitable habitat for the pest. Additionally, cultural and socioeconomic characteristics unique to a given population may accelerate the development of certain architectural and sociodemographic features. The primary objective of the following study was to identify these features and to create a model for predicting the likelihood of developing allergies to certain pests in the event that these features are present.

The following paragraphs present an elaborated view of the epidemiological transition of disease. Following this presentation, the evolutionary perspective of allergy will be discussed, so as to better understand the interrelationship between the physiological and cultural elements of allergy.

Defining the Epidemiological Transition

An interesting characteristic of many of the contemporary, chronic diseases is that they are particularly prevalent and "epidemic"-like in transitional societies, or those populations undergoing the shift from develop<u>ing</u> to develop<u>ed</u> modes of production. In developing countries, many of the chronic diseases associated with the epidemiological transition appear first in members of the

upper socioeconomic strata (Burkitt 1973), probably because of their access to Western products and practices. The diseases typically share common, etiological factors related to human culture, including diet, activity level, mental stress, behavioral practices, and environmental pollution.

There are a number of contemporary chronic diseases that may be used to exemplify the epidemiological transition model. Biocultural anthropologists have investigated dietary changes as an important etiological factor for the development of many chronic diseases. Burkitt (1973) notes that while the intake of fiber in British and American diets between 1880 and 1960 fell by more than 90%, fat consumption increased, and sugar consumption doubled. A low fiber, high fat diet seems to have the greatest effect on the development of noninfective bowel disease, including diverticular disease, appendicitis, colon cancer, polyps, and ulcerative colitis (Burkitt 1973). Similarly, high serum cholesterol has been widely discussed as a major factor in coronary heart disease (the number one cause of death in developed countries) and gall-bladder disease (Burkitt 1973). Obesity and high intakes of refined carbohydrates are related to the increasing incidence of heart disease and diabetes. Diabetes is particularly high in groups undergoing the transition from traditional life-style to "modern"; certain urban groups of the Bantu in South Africa have rates 40 times greater than their

counterparts in the rural sector (Pelto & Pelto 1983). Similarly, many Amerindian groups, including Mexicans, experience unusually high incidences of obesity, adult onset diabetes mellitus, and gallbladder disease; this has been termed the "New World Syndrome" of disease (Weiss et al. 1984). Obesity is considered to be the most common form of malnutrition in developed countries (Burkitt 1973; Pelto & Pelto 1983) and is a direct result of an increasingly sedentary life-style (which reduces caloric needs) in conjunction with steady or increasing caloric intakes.

Medical technology has succeeded in eliminating many of the communicable diseases that reduced whole populations (e.g., the Black Death in Europe, smallpox in the Americas), and chemotherapies and immunizations have the potential to control a majority of other infectious diseases. It has been calculated that public health measures alone (e.g., clean water and sewage provisions) increase life expectancy in a population to almost 65 years (Baker 1989). The control of infectious and communicable disease, resulting in increasing life expectancies, has paved the way for degenerative disease.

A feedback effect of medical technology is a shift in demographic trends, whereby the rate of fertility continues at a steady state while mortality drops sharply. The eventual matching of fertility rates with mortality rates is referred to as the "demographic transition," and this is the

current pattern in most of the developed countries (Baker 1989). However, societies in transition are slower to achieve the equalizing of fertility with mortality, probably largely due to the suddenness of changes in mortality rates. The continuing increase in population size in conjunction with an increase in commercialization of agriculture--characterized by a reduced need for workers in the rural sector and malnutrition--has had particularly detrimental effects on the urban environment in transitional societies. These urban environments are characterized by over-crowded living arrangements, underemployment or unemployment, and a chronic state of infectious disease (e.g., tuberculosis, filariasis) for which biomedical treatments are not always available (Miller 1973), plus the introduction of many of the chronic, "modern" diseases.

While degenerative diseases are characteristically higher in persons of older age, they are not limited to that population. Baker (1989) argues that degenerative diseases are not necessarily an inevitable process of ageing, because many of them (e.g., myopia, high-frequency hearing loss in middle-age) are completely absent in some groups. Similarly, while malignancies can be found in all human populations, and for that matter, other animals, the types and locations of malignancies vary from traditional populations to "modern" populations (Baker 1989).

A unique characteristic of the chronic diseases is their relatively recent appearance in human history as a major cause of morbidity. According to Corruccini and Kaul (1983), this is indicative of a strong environmental factor in disease etiology. Indeed, all of the above disease-causing factors are those created by humans and their culture. While biological factors such as genetics are no doubt important in determining who is most likely to succumb to which disease, genetics alone cannot explain the rapid spread of chronic disease. Our genetic systems simply do not operate in selecting for or against certain physiological features in such a short period of time.

When evaluating the epidemiology of a specific disease, what we see in developed countries is the end result of the epidemiological transition; at this level it is difficult to identify specific socio-environmental variables that are responsible for the disease process. By including in the epidemiological analysis less-developed societies and their socio-environmental variables, we create the "whole picture," or the evolutionary perspective of that disease. By analyzing the natural history of a disease in different societies and the different human behaviors associated with the distribution of that disease, we will be able to identify disease-causing variables and predict epidemiological outcomes. This information can then be applied to health education, and preventive medicine may, in

the ideal setting, be used to minimize the effects of that disease.

Allergy is an excellent example of a disease which is part of the epidemiological transition. As heretofore described, allergy is uncommon in traditional societies, reaches epidemic rates in transitional groups, and is increasing in developed populations where it is most common overall. Prevalence of allergy is characterized by the degree of modernization within a population, for reasons similar to--and in some ways quite different from--the typical chronic diseases.

Disease Ecology and the Evolution of Human Allergy

The theoretical framework most commonly used in understanding the evolution of human disease is based on the triad of host, pathogen, and environment. The current ecological perspective places the most emphasis on the environment and gives equal attention to both the physical components (e.g., geologic, climatic, biotic) and the cultural components (e.g., technological, social, and ideological). The host represents both the individual and the population and is responsive and constantly rallying to maintain homeostasis. The pathogen is any insult against the host.

The evolution of human disease has closely paralleled the evolution of human modes of subsistence practice, and this is probably why so many biocultural anthropologists

have referred to the different subsistence periods in human history as a construct for analyzing disease evolution (Cockburn 1971; Dunn 1977; Armelagos & Dewey 1978; Baker 1989; Armelagos et al. 1990). Subsistence modes dictate, to a degree, biocultural factors such as demographics and dietary practices.

Disease in Pre-State Society

Humans and their predecessors relied on hunting-gathering as a means of subsistence from about four million years ago until the beginning of the neolithic, some 11,000 years ago. Hunter-gatherers utilize as many edible products as possible, including a variety of protein and carbohydrate sources as food, and have well-balanced diets. (There are exceptions; for example, Arctic aboriginals have evolved physiological and cultural mechanisms whereby they survive on a diet with little variation, mostly composed of animal protein.) Hunter-gatherers are mobile for the purpose of finding new sources of food after a particular region has been exhausted and are small in population size to facilitate that mobility. Their mobility negates the possession of many nonconsumable goods; therefore, their living quarters are simple and constructed of the ecological materials readily available to them. Because of the large area of land needed to support their subsistence, there is limited contact with populations outside of the immediate group.

Due to the small population size of early hunter-gatherers, there were a limited number of infectious diseases that could have established a symbiotic relationship with human hosts. This factor highlights several epidemiological principles essential for understanding the evolution of human disease. Pathogens (a collective term used here to represent bacteria, viruses, fungi, spirochetes, and the parasites, including protozoa, helminths and arthropods) must, in order to survive, affect low mortality among their hosts. An underlying principle when determining the evolutionary association between a pathogen and a host is that the more stable the host-pathogen relationship, the longer the two likely have coexisted. In contrast, more pathogenic relationships are assumed to have been recently developed, because they apparently have not evolved a stable relationship. The elaborate relationship that helminths have developed with human hosts is indicative of their long history with hominoids. For example, no single helminth parasite is limited to humans as a necessary host, and all of them have avoided the development of complete immunity in the human host. This lack of immunity probably is indicative of the very low mortality caused by helminths and complete immunity is therefore not essential for the host's survival (Kliks 1983). An exception to this principle are pathogens that

cause high mortality--such as tetanus--but do not require the host for their survival.

Another epidemiological principle is that the more pathogenic the insult by the organism, especially against hosts of a pre-reproductive age, the greater the selective pressure will be on the population (Kliks 1983). Diseases that produce low pathogenicity or are chronic and therefore affect the post-reproductive population will exert less selective pressure. Physiological adaptation (e.g., in the form of acclimation, accommodation, or acclimatization) is a response to selective pressures by which a host improves his/her chance to rally against pathogenic insults, and may take the form of genetic changes or physiological responses completed within a single life span. Cultural "adaptation" includes responses by which information is transferred to subsequent generations to enhance survival in a given environment. Genetic changes are the slowest adaptations to evolve and signify long-term coexistence.

Many of the infectious diseases require large host populations and rapid transmission time for their survival. This is referred to as the population "threshold level" (Cockburn 1971). If a host population is not a minimal size for pathogen maintenance, then the pathogen will die. Typically with infectious diseases large host populations are required; the acute communicable infections of cholera, rubella, smallpox, mumps, and measles are examples. The

population threshold is not necessarily due to mortality, because even pathogens that can live as commensals within the host often will die in a small community (Cockburn 1971). Furthermore, organisms that are highly pathogenic often elicit an immune response, that subsequently limits the number of susceptibles in a small population.

Two types of infectious diseases have been recognized as affecting early hunter-gatherers: those which had existed among the prehominids and persisted in the hominids and those that were accidentally encountered from other animals (zoonoses) by means of vector, wounds, or consumption of animals (Polgar 1964). Cockburn (1971) listed a number of intestinal parasites, ectoparasites, treponemal infections (including yaws), malaria, and several viruses (herpes and hepatitis) that were present in primates prior to the first humans. Many of the zoonoses were acquired after eating infected or raw mammals, insects, birds, and fish, the most common of which were probably anthrax and botulism (Cockburn 1971). Zoonotic diseases also were spread by arthropod vectors. Avian, or ichthyic, tuberculosis was a disease of early humans (Cockburn 1971), as was schistosomiasis (Baker 1989).

Hunter-gatherers rarely experienced malnutrition or starvation, and chronic disease was infrequent (Dunn 1977). Nevertheless, life expectancy was relatively short, rarely longer than 30-35 years, with few living longer than 50

years (Baker 1989). It is believed that traumatic and accidental death was the leading cause of mortality, including falls, snakebites, and death by predators. Social mortality involving infanticide, homicide, suicide, war, and cannibalism was also a factor in mortality (Dunn 1977; Baker 1989).

Disease in State Society

The shift to agricultural forms of subsistence some 10,000 years ago marked some of the most significant changes in culture since humankind's emergence. Large-scale production of food changed the nomadic life-style of the hunter-gatherer to a sedentary one. This resulted in the accumulation of goods and the advancement of technology, thus promoting the division of class and trading and communication with other populations. To plant and harvest farms and to replace animal sources of protein lost after clearing land for the farms, many groups domesticated and herded animals.

All of the above either directly or indirectly contributed to human disease, most notably infectious disease. The concentration of large numbers of human hosts in a permanent location provided the "threshold" population level necessary for the communicable diseases as well as the vector-borne diseases. The sedentary life-style resulted in a build-up of human waste proximal to living quarters and water supplies, which promoted disease from parasites such

as the ascarids and hookworms. Contact with other populations facilitated the spread of infectious disease to epidemic proportions by providing organisms with "virgin" hosts. New zoonotic diseases were encountered with the constant contact of domestic animals, including anthrax, brucellosis, tuberculosis, and Q fever (Polgar 1964). Unwanted peri-domestic animals such as rodents and sparrows developed permanent habitats in and around human dwellings.

By 3000 B.C. cities with populations of 50,000 or greater were established in the Near East (Armelagos et al. 1990). All of the characteristics of the earlier agricultural populations were present, but on a much larger scale. There were increasing difficulties with supplying water and food and with managing human waste, resulting in outbreaks of cholera (Armelagos & Dewey 1978). Increasingly complex societies also resulted in a breakdown of traditional social practices; one example is the increase in sexually transmitted diseases as a result of sexual promiscuity (Armelagos & Dewey 1978). The same communicable diseases that affected earlier agriculturalists continued, but for the first time the populations were sufficient for maintaining an endemic form (Armelagos et al. 1990). Yet what was endemic to one population was often detrimental to another. Cross-continental trade and exploration resulted in intense epidemics (Zinsser 1936; McNeill 1976; Laird 1989). Large-scale wars resulted in some of the most

serious epidemics in history. Following the introduction of Rattus into Western Europe by the Crusaders and the introduction of the Xenopsylla cheopis flea by seaborne vessels, the Black Death began to take its toll in Europe in 1347 and, three years later, had eliminated at least a quarter of the European population (approximately 25 million people) (Laird 1989).

With increasing developments in technology evolved the germ theory. A better understanding of disease causation has admittedly resulted in increasing control over infectious diseases. With the discovery of immunization came the eradication of smallpox, and most of the other communicable diseases have diminished in distribution. The decrease in infectious disease has resulted in greater life expectancies, so that chronic, degenerative diseases have become the focus of morbidity and mortality. It has also resulted in higher fertility rates producing worldwide population explosions and leading to overcrowding, underemployment and unemployment, and subsequently all of the diseases associated with poverty.

Recently, much attention has been focused on the detrimental effects of industrialization on the international environment, including water, land, and atmosphere. Massive industrial production of commodities has caused pollution of much more than human waste. Increasingly, there is concern over the health implications

of contaminated water supplies, overuse of pesticides in commercialized agriculture, atmospheric chemicals, and the future effects of a depleted ozone on human health and food production. Increasing incidences of cancer among young people and the increase in respiratory disease has been implicated in these environmental changes. While most of our current chronic diseases and conditions most certainly existed in early populations (e.g., dental malocclusion, myopia, and allergy) they must have been rare in order for those populations to have survived without the technological compensations which we know today, and their relatively sudden appearance on such a large scale suggests an environmental causation (Burkitt 1973; Corruccini & Kaul 1983).

Application of the Disease Ecology Model: Allergy

Clearly, human biological and cultural activities interacting with the environment forged lasting yet dynamic relationships between host and pathogen. However, the effects are two-way. Until this point I have focused on how human evolution has influenced disease, but at least as important is the issue of how disease has influenced human evolution. This has stimulated countless biological and cultural adaptations so that the host--individual or population--may be returned to a steady state of well-being. In many instances these adaptations have feedback effects on the disease ecology.

The effect of disease on human evolution can be summarized as follows: as humans evolved from one stage of subsistence to another, they increasingly altered their environment, thereby promoting new diseases which did not exert selective pressures on previous populations to the same degree. These newly encountered diseases forced biological and cultural adaptations on the population, compelling society to alter or increase food production, explore new territories for new resources, and advance technologically to combat the insults. Because no two environments or no two gene pools are identical, different diseases evolved for different populations. With increasing communication between groups, there was an increase in the distribution of disease. This "evolution" is circular; disease forced changes in the host and her/his environment, changes were made, and new diseases arose, forcing more change.

The evolution of human allergy is an excellent illustration of this feedback effect. Allergy is an example of how a disease response (hypersensitivity) possibly evolved as an adaptation to another disease early in human history and how this "adaptation" is currently causing negative feedback effects on contemporary disease ecology.

The Influence of Disease on Biological Adaptation: Parasitic Infestations and IgE

At the beginning of this essay it was noted that the earliest diseases affecting humans were those which had affected the prehominids and zoonoses. It was also noted that one of the "epidemiological principles" is that the more stable the host-pathogen relationship, the longer the two have probably coexisted. Helminths were illustrated to have evolved this type of relationship with human hosts, and the very long history of that relationship and low mortality are evident in that all of the helminths have avoided the development of complete immunity in the human host, indicating that complete immunity is not an essential feature for the host's survival (Kliks 1983).

Given that parasites and humans coexisted for such a long period, one would assume that the disease might have influenced some sort of biologically adaptive means for minimizing the pathogenic effects in the human host. We already know, for example, some of these adaptive mechanisms. Many of the parasites have evolved mechanisms for assuring the survival of the host, as in concomitant immunity, in which the adult worms prevent the survival of subsequently acquired larvae of similar or different species (Kliks 1983). The effects of more elaborate genetic adaptations have also evolved (e.g., sickle cell trait), which are specific to a parasitic species. Researchers examining contemporary populations chronically infested with

parasites observe another common feature: stimuli that cause some of the highest titers of serum IgE are the protozoa and helminths (Johansson et al. 1968; Ito et al. 1972; Bazaral et al. 1973; Desowitz 1981; Sher & Ottesen 1988). Yet, while serum IgE is 10 times higher in people with allergy than in normal people, IgE is 10 times higher in people with parasitic infections than it is in allergics (Sher & Ottesen 1988).

There are five immunoglobulins in the human immune system: they are, in order of concentration, IgG, IgA, IgM, IgD, and IgE. Immunoglobulins are more generally referred to as antibodies and are produced from lymphocytes. Of all the human immunoglobulins, the least is known about immunoglobulin "E," referred to as IgE. Elevated IgE is found only in two clinical conditions: helminthic infestations and allergy. Allergy is the common name for "hypersensitivity," or an inappropriate response to a harmless antigen upon second contact with that antigen. There are four types of allergic reactions, but "allergy" generally refers to the Type I reaction, also called immediate type hypersensitivity. The main mediator in Type I hypersensitivity is IgE.

IgE is dispersed both free in the serum and bound on the surface membrane of mast cells and basophils. Serum IgE is very low in comparison to concentrations of other immunoglobulins, typically ranging from 10 to 100

nanograms/ml, or, put another way, is less than 0.00001 of all the body's total immunoglobulins (Johansson & Bennich 1985). IgE is unique among the classes of immunoglobulins; although its normal concentration is extremely low, it may increase several hundredfold following challenge to a specific stimuli (Barbee et al. 1981).

Allergenic stimuli are referred to as allergens or antigens. Antigens may be inhaled, injected, ingested, or presented by dermal contact. When IgE comes into contact with an antigen, it triggers the release of the contents in the basophils and mast cells. These mediator substances include: histamine, a vasodilator; slow-reacting substance of anaphylaxis (SRS-A), a smooth muscle contractor; and the eosinophil chemotactic factor of anaphylaxis (ECF-A), which causes the accumulation of eosinophils where the interaction occurs. The clinical feature of Type I hypersensitivity is referred to as "atopy." Atopy can be manifested as asthma, allergic rhinitis, or eczema, sometimes called dermatitis (not to be confused with "contact dermatitis" which is a manifestation of Type IV hypersensitivity). Atopic individuals are, in the most extreme scenario, at risk of anaphylaxis, a life-threatening reaction in which there is vasodilation and constriction of smooth muscles, particularly of the bronchus, thus interrupting the exchange of metabolic gases.

The capacity for developing elevated levels of serum IgE is largely determined by genetics. This predisposition is controlled by the major histocompatibility complex, or MHC (antigen-specific) and by a regulator gene (nonspecific) (Menser et al. 1975; Marsh et al. 1981; Marsh et al. 1980b). Prevalence of atopy is higher in non-European descendants living in developed countries (Davis et al. 1961; Worth 1962; Orgel et al. 1974; Marsh et al. 1980a; Waite 1980).

While the functions of IgG, IgA, IgM and IgD are relatively well understood, the physiological function of IgE is less clear. IgE is important in facilitating fluid transport across cell membranes, and it also functions in fighting bacterial and viral disease, although to a much lesser degree than the other immunoglobulins (Gerrard 1985; Johansson & Bennich 1985). With increasing evidence of a relationship between elevated IgE and parasitic infestations, researchers began to determine what the physiological relationship was between the parasite and the immunoglobulin.

Animal studies demonstrated that serum IgE appeared to function by minimizing the number of parasites in a host who was chronically exposed to large numbers of parasites (Hsu et al. 1974; Dessein et al. 1981). Dessein et al. (1981) concluded that IgE-suppressed rats demonstrated significantly less resistance to infection by *Trichinella spiralis* than controls with normal IgE levels. Following

sequential challenges with Schistosomula japonicum cercariae to a rhesus monkey, hypersensitivity reactions were determined using microscopic examination of skin biopsies and macroscopic determinations (wheal and flare) (Hsu et al. 1974). The schistosomulae were destroyed in the dermis of the primate approximately 12 hours after the challenge.

After numerous other laboratory and clinical studies, contemporary immunologists concluded the following protective mechanism of IgE against heavy parasitic infections: upon entering the host, soluble parasitic antigens diffuse across the intestinal mucosa and are transported to the lymph nodes, where an IgE-mediated response occurs. Mast cells migrate to the same lymph nodes, are sensitized by the development of parasite-specific IgE on their surface, and return to the intestinal mucosa. Upon contact with the parasitic antigen, the mast cells degranulate and release their mediators, which subsequently attract to the site eosinophils, complement, and parasite-specific IgG, all of which function to damage and expulse the parasite (see Brothwell 1972).

Having reviewed the relationship between parasitic infections and IgE, and with the understanding that the only other manifestation involving elevated IgE is allergy, the question is posed: is there any relationship between parasitic infections and allergy? Unfortunately, this relationship is much less clear than the helminthic-IgE

relationship. Before discussing what is known about this topic, a review of the evolutionary history of IgE as an adaptive process will be presented.

The Influence of Disease on Cultural Adaptation: The Gradual Decrease in Exposure to Parasites

With the confirmation of a relationship between IgE and both allergy and parasitic infestations, there have been a number of suggestions as to a "cause-and-effect" relationship between the two. From an epidemiological point of view, this information would be valuable in determining the distribution of IgE-related disease in populations of the past and predicting trends in contemporary societies.

The first evidence of a relationship between IgE and parasites ironically came from a temperate environment rather than the tropics, where parasitic infections are typically endemic. D. Tullis (1970) declared that an unusual epidemic of *Ascaris lumbricoides*, *Trichuris trichiura*, *Necator americanus*, and *Ancylostoma duodenale* in the Niagara Falls vicinity had coincided with an alarming increase in the prevalence of asthma. One-hundred and ninety-eight of the 201 asthmatics were diagnosed with intestinal infestations involving one or several of the above parasites. Tullis' conclusion was that there was a definite correlation between the development of bronchial asthma and intestinal parasitic infestations. Following Tullis' report, other immunologists published similar findings,

concluding that parasites caused allergy (Huntley 1976; Joubert et al. 1980; Desowitz et al. 1981).

The investigation was taken to the tropics where populations traditionally have experienced high levels of parasitic infections. As expected, and similarly to the previous studies, populations that were heavily infested with parasites demonstrated extremely high levels of IgE (Godfrey 1975; Warrell et al. 1975). However, one researcher, Godfrey (1975), noted in his study that, among those patients with the extremely high serum IgE and parasitosis, allergy was practically nonexistent. Furthermore, he added a socio-demographic variable, concluding that parasitosis was highest in the rural region and asthma was highest in the urban region, where there was a low incidence of parasitosis. Similar experiments in laboratory settings revealed the same results; allergy was minimized or absent in persons with heavy parasite infections (Phills et al. 1972; Hsu et al. 1974; Godfrey & Gradidge 1976; Dessein et al. 1981).

Curiously, other studies indicated that there was no relationship between IgE, parasitic infections, and allergy; atopy was just as prevalent in persons with helminthic infestations as without them (Alcasid et al. 1973; MacFarlane et al. 1979). These studies did not, however, take into consideration various socioeconomic and demographic variables, such as urban or rural residence.

The prevailing conclusion is that, under certain conditions, all three of the above scenarios may occur. But in the majority of cases involving heavy parasitosis in endemic regions, the incidence of allergy to both parasites and exogenous allergens is low. The mechanism for that suppression is believed to be one of the following two theories. Chronic exposure to large numbers of parasites stimulates the production of both specific and nonspecific IgE antibodies, resulting in "saturation" of the IgE receptors on the mast cells and therefore preventing the cell from responding to additional "specific" antigens, such as molds or arthropods (Godfrey & Gradidge 1976; Ottesen 1985).

A second--and currently more widely accepted theory of mechanism--is a "blocking antibody" mechanism, in which persons chronically exposed to helminths produce antigen-specific IgG-blocking antibodies which inhibit to a degree the mast cell or basophil degranulation process (Ottesen 1985). Similar to other mechanisms involving human hosts and parasites, the potential role of these antibodies appears to be more to limit the degree of hypersensitivity rather than to eliminate the reaction completely (Ottesen et al. 1981; Ottesen 1985). This mechanism is specific for maintaining a low incidence of allergy to parasites rather than exogenous allergens and is not recognized in atopic disease (Ottesen et al. 1981). It is, interestingly, also

the principle for which desensitization therapy for allergic disease is administered (Ottesen et al. 1981; Ottesen 1985).

The blocking antibody theory explains why allergy to helminths usually is seen only in the early phases of parasitic infestation. At the sites of initial parasitic contact, such as the mucous membrane or skin, the antigen concentration is too great to succumb to the effects of the blocking antibodies, yet as the parasitosis progresses and sufficient IgG-blocking antibodies are generated, the hypersensitive reaction gradually would be controlled (Ottesen 1985). Consequently, in regions where helminthiasis is in an acute, epidemic stage (e.g., Niagara Falls) allergic responses to the helminths would be expected.

A blocking mechanism specific for helminths--but not for other allergens--would also explain why helminthiasis and allergy occasionally occur simultaneously. Populations that have been chronically exposed to parasites have a genetic predisposition for elevated IgE. It is likely that the occurrence of both phenomena is reflective of populations undergoing a transition from develop<u>ing</u> to develop<u>ed</u> living conditions, as in rural to urban migrations in tropical countries, where they are exposed to both parasites and new and numerous exogenous allergens.

Clearly, there is a cause-and-effect mechanism between IgE and both helminthiasis and atopy. However, the sum

process is multi-causal. First, predisposition to develop high levels of serum IgE is genetically-determined. The fact that these elevated levels are higher in non-Europeans than Europeans has already been mentioned. Presumably, the selective advantage for a haplotype which is predisposed to producing high levels of IgE--a key component the mechanism for destroying invading helminths--would be highest in a population chronically exposed to helminths. This represents the protective role of IgE. Over millennia, and following the cultural impact of widespread distribution of once isolated gene pools, these haplotypes would also be widely dispersed. Elevated IgE in populations chronically exposed to parasites apparently did not produce adverse health effects due to the check-and-balance mechanism of IgG-blocking antibody and the control of the hypersensitive state. This mechanism was advantageous to both the host and pathogen. Without exposure to helminths, however, there is apparently no IgG-blocking antibody and therefore no built-in control over the immune response in the event of contact with foreign allergens. This is the negative feedback component of the immune mechanism. Traditional societies exposed to many parasites--but few exogenous allergens in a less complex environment--benefitted from the biological adaptation of IgE; parasitosis was kept at a reasonable state of low morbidity. Yet as humans evolved culturally and biologically, they created an environment in which IgE

is not checked (e.g., no exposure to parasites) and in which potential allergens abound.

In summary, it is apparent from this particular illustration--IgE, helminths, and parasites--that disease plays a major role in the adaptation of the human host, but that many adaptations may in turn promote additional diseases. A new trend in the ecological perspective of disease is to shift our focus on adaptation as an "optimal" mechanism to one of sufficiency. Gould and Vrba (1982) argue that, in the case of evolution, the word "adaptation" has been overused, because not all features that enhance fitness were necessarily designed by natural selection for their contemporary role. The authors suggest that "exaptation" be used to explain certain characters that either evolved for other purposes or for no purpose at all, but were later "co-opted" for a contemporary purpose (Gould & Vrba 1982).

Although "exaptation" may not be an appropriate description for the development of IgE, we cannot eliminate it as a possibility. Perhaps IgE did originate for a similar purpose as the other immunoglobulins, but was also efficient in functioning as an anti-helminthic mechanism. By adopting this approach, we may include in our analysis of human evolution other traits which have previously received little attention, because "complete" adaptation was not the end result.

Influencing Biological and Sociocultural Factors

People who live in developing regions of the world do not exhibit a high prevalence of allergic disease (Godfrey 1975; Warrell et al. 1975) presumably because of functioning IgG blocking-antibody. This is probably because exposure to parasites is chronic due to their traditional modes of production and because they have limited sources of clean water and sanitary provisions. When they shift to a more developed, urbanized environment the incidence of allergy becomes comparable to incidences in developed countries. This is, however, an over-simplification of the allergy model. A number of biological and behavioral factors contribute to allergic disease, as will be demonstrated below.

Genetic, MHC-related factor

The development of allergic disease in an individual is multi-causal. Perhaps one of the most predictive factors for the development of allergy is genetic predisposition; some individuals are genetically predisposed to produce more IgE than others (Willcox & Marsh 1978; Marsh et al. 1980b; Gerrard 1985). The phenotype of elevated serum IgE is at least partly dictated by a genotype controlled by the MHC. The MHC is a region on chromosome 6 in humans that contains a number of gene loci. A particularly important complex is composed of the four human lymphocyte antigen (HLA) loci, designated as HLA-A, -B, -C and -D. Each locus contains a

number of different alleles, or HLA antigens, resulting in a high degree of polymorphism. A set of HLA genes (that includes four HLA determinants) constitutes a "haplotype". Certain HLA antigens--or haplotypes--have been correlated with immune responsiveness to aeroallergens (Menser et al. 1975; Blumenthal et al. 1980; Marsh et al. 1980b; Marsh et al. 1981; Brostoff & Hall 1989). For example, HLA-Dw2 is highly associated (92%) with allergy to the short ragweed allergen Ra5, in contrast to a poor association (22%) for those individuals with HLA-B7 (Marsh et al. 1981).

Genetic, non-MHC-related factor

High IgE levels are also dictated by a regulator gene that is not linked to the MHC; total IgE is partially regulated by an autosomal gene in which the genotype that controls for high serum IgE is recessive (rr) and low total IgE is dominant (Rr or RR) (Marsh et al. 1974; Gerrard et al. 1978; Willcox & Marsh 1978; Marsh et al. 1980b; Rao et al. 1980). It is postulated that the dominant allele (R) functions by limiting the number of IgE antibodies that clonally expand in response to an allergen, resulting in low total serum IgE (Willcox & Marsh 1978). While the MHC class of immune response (Ir) genes are antigen-specific, this second genetic mechanism involving the regulator allele "R" is nonantigen-specific (Willcox & Marsh 1978; Marsh et al. 1980b).

Familial factors

Predisposition to allergy is associated with a positive family history of allergy (Gerrard et al. 1976; Gerrard et al. 1978; Marsh et al. 1980b), although the familial environment might be a more important factor; members of a family living in the same household and sharing the same behaviors might all be at a similar risk of developing allergies. Nevertheless, results from studies involving twins conclude that serum IgE is genetically determined and monozygous twins express more similar levels of IgE than dizygous twins (Bazaral et al. 1974).

Ethnic factors

Prevalence of clinical allergy reportedly has been higher in non-European descendants living in developed countries, including the following: Chinese Americans (Worth 1962); West Indian Blacks in England (Davis et al. 1961, Pearson 1973); American-born Filipinos (Orgel et al. 1974); and Polynesians in New Zealand (Waite 1980). Similarly, Iraqi, Iranian, and Yemini immigrants in Israel had higher rates of asthma than other ethnic groups (Asch et al. 1973). In contrast, some races exhibit a lower prevalence of allergy than European-descendants; Herxheimer & Schaefer (1974) reported that the incidence of asthma among Canadian Eskimos was extremely rare. Asthma was also rare for North American Indians despite their unusually high levels of serum IgE (Gerrard 1985). It has been suggested that the

low incidence of asthma among Canadian Eskimos and North American Indians may be related to the low frequency of HLA-A8 haplotype in that population; white children with HLA-A8 have a particularly high incidence of asthma (Menser et al. 1975). However, Gerrard (1985) noted that serum IgE levels were high in the Indian population; he hypothesized that inadequate medical services meant that the North American Indian was forced to rely more heavily on his/her own immune system, possibly resulting in higher IgE levels.

Behavioral and nutritional factors

Similarly to other chronic diseases of modernization, genetics alone cannot explain the rapid increase in the prevalence of allergy. Just as the environment probably was important for the development of IgE--that is, exposure to an environment plagued with intestinal helminths--so the environment must be important for the development of another IgE-related manifestation: Human allergy. After all, elevated IgE cannot manifest itself as a hypersensitive reaction unless there is some aggravating allergen present to elicit the response.

One factor characteristic of modernization and important in the development of allergy is both biological and behavioral, and that is breastfeeding. Breastfeeding is believed to decrease the likelihood of developing allergy indirectly by minimizing infection. Breast milk contains factors that promote the maturation of the intestinal tract

of the newborn and also provides secretory antibodies to assist in immunity at the intestinal surface (Ogra & Ogra 1978). Also, breast milk contains fewer foreign proteins than bottled milk and it is believed that both the introduction of foreign antigens (Johansson & Bennich 1985) and infection during early childhood (Marsh et al. 1981) may initiate allergic disease.

It is often difficult to differentiate between true food allergies and genetically-based food intolerances (<u>see</u> Lieberman & Barnes 1990). A number of the food intolerances (e.g., celiac disease, G6PD-deficiency, and lactose intolerance) have been managed by culture-specific proscriptions and food preparation practices in regions where they are most commonly distributed. However, when individuals with food intolerant predispositions are exposed to new foodways, either voluntarily or involuntarily, adverse allergic-like reactions often occur. Newly introduced sources of dietary proteins--particularly the oil seeds and yeasts--as well as the chemical modification of foods for large-scale commercialization have potentially antigenic effects on persons predisposed to allergic disease (Metcalfe et al. 1988). A well-publicized phenomenon is the "Chinese Restaurant Syndrome," which is an adverse food reaction to monosodium glutamate (MSG) (Man-Kwok 1968; Allen & Baker 1988).

Miscellaneous behavioral factors

Other behaviors associated with modernization contribute to the development of allergy. Cigarette smoking is associated with elevated serum IgE (Gerrard 1985; Burrows 1989). Psychological stress has been implicated in at least the exacerbation of allergy and possibly as a predisposing factor (Graham 1967; Glazer 1969; Smith 1978). Stress is a well-known insult in populations undergoing transitions from rural to urban settings, immigration, and an increase in complexity of modes of production (McElroy & Townsend 1985; Goodman et al. 1988). The disproportionately high levels of allergy among Iraqi and Yemeni immigrants into Israel was partially attributed to psychological stress (Glazer 1969).

Population behavior and the macroenvironment

As the environment in which we live becomes more complex and we become more mobile, we are increasingly exposing ourselves to greater numbers of foreign proteins that may function as allergens. Immunologists conducting studies in tropical regions have found that prevalence of allergy tends to be much lower in populations where traditional means of living continue compared to prevalence in more developed populations (Anderson 1974; Godfrey 1975; VanNiekerk et al. 1979; Dowse et al. 1985). Specifically, urban populations overwhelmingly present with higher rates of allergy than rural populations, and this discrepancy is most notable in developing countries; examples include the

Gambia (Godfrey 1975), Nigeria (Warrell et al. 1975), and the Punjab (Corruccini & Kaul 1983). With the process of urbanization and modernization, populations are subjected to new foods, ingested chemicals, and synthetic materials, as well as chemicals and pollutants emitted into the environment from factories and transportation vehicles. Urban pollutants such as sulfur dioxide, sulfuric acid, carbon monoxide, and particulate matter serve as irritants to asthmatics (Lopez & Salvaggio 1978; Smith 1978; Hackney & Linn 1985; Weiss & Speizer 1985).

Population behavior and the microenvironment

The role of the domestic environment--or rather, "microenvironment"--was discussed at the outset of this chapter. Specifically, some of what is known regarding allergens and the microenvironment is related to the presence of arthropods. Also important is the production of molds (Burr et al. 1985; Brunedreef et al. 1989; Platt et al. 1989; Dales et al. 1991) and fungi (Arundel et al. 1986; May et al. 1986) secondary to excessive moisture levels in the home. Inadequate ventilatory practices in housing construction contribute to elevated relative humidity levels (Arundel et al. 1986).

Conclusions and the Allergy Disease Model

Figure 1-1 illustrates the cultural and biological factors sufficient--but not necessary--for the development of allergic disease. The biological and cultural factors

are a result of interactions between the host population and the environment; both factors influence each other, <u>from</u> the host, and <u>to</u> the host. These interactions create elements in the environment that subsequently produce allergenic stimuli, or "insults", which in turn affect the host. Depending on inherent features of the host, they may or may not produce disease.

In summary, by reviewing many of the known factors for the development of the hypersensitivity response, it is evident that allergy is a disease characterized by human modernization and urbanization. By using the construct of the epidemiological transition we can predict the development of allergy as a significant form of morbidity due to changes which typically occur during the transition of traditional living toward modern living. It is apparent that populations in the middle of this transitional period will experience an epidemic-like form of the disease due to the sudden exposure to numerous allergens. Many of those individuals may be more likely to suffer from allergy because of their genetic make-up, although this is not a limiting factor. Evaluation of disease patterns outside of the Western world and into regions where the disease-causing relationship begins will provide medical researchers with new insights into the evolution of many human diseases--in this case, allergy.

Notes

1. "Arboallergen" is a term used to denote any arthropod-borne allergen. It is based on the hypothesis that a number of specific epitopes are found in different arthropods, and possibly occur in proteins associated with the production of chitin and molting and/or in common digestive enzyme systems (Brenner et al. 1991). The resulting clinical picture is cross-reactivity (hypersensitivity) to different arthropods.

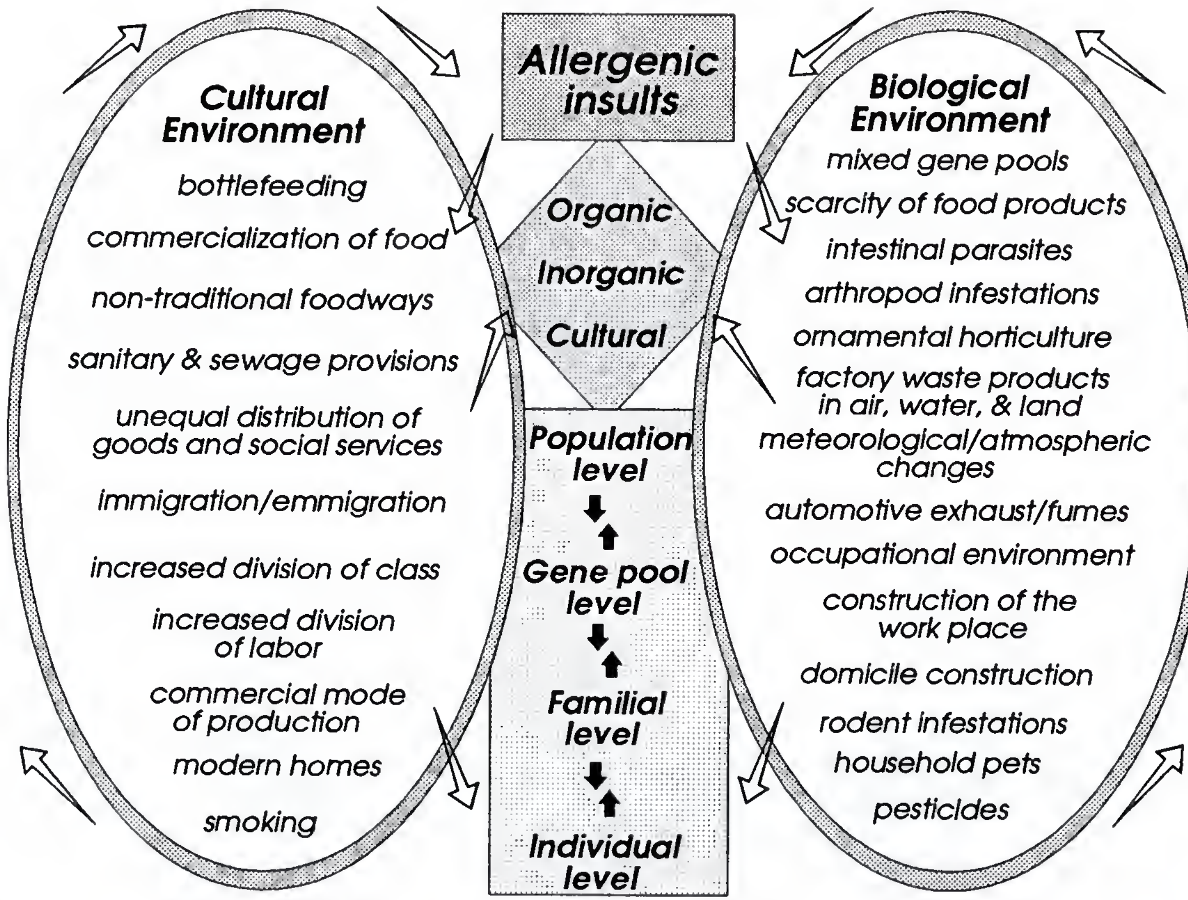


Figure 1-1. The Allergy Disease Model in the Ecological Perspective.

CHAPTER 2
THE STUDY DESIGN AND RESEARCH SETTING

The Construct of Allergy and Modernization: A Review of the Objectives

In Chapter One, allergy was defined as part of the epidemiological transition of disease and both genetic and behavioral factors were identified that are known to contribute to the rising incidence of allergy on a worldwide scale. It was suggested that a closer look at a population in the midst of infrastructural transition may elucidate factors that are playing a significant role in the incidence of allergy in both societal settings--develop<u>ed</u> and develop<u>ing</u>. Certainly, identifying etiological factors of disease is more complicated in a developed society, after the epidemiological transition has occurred, in that the population as a whole has already achieved a certain degree of adaptation in its effort to rally against the disease, and it is therefore difficult to distinguish between causal versus spurious co-variation of suspected independent variables.

The overall objective of the study--identifying a relationship between modernization of the domestic environment and allergy to household pests--was presented in Chapter One. The dependent variable in the study is allergy to a given household pest at the individual level, a

biological measurement to be presented categorically; a person is either reactive or nonreactive to a specific pest allergen. To minimize variation in selection criteria and symptomatology associated with atopy, only asthmatics were chosen for the study. The independent variables in the study are structural features of the domestic environment and sociodemographic features of the household that may contribute to the nutritional and reproductive needs of various household pests, thus supporting a substantial population of the pests. The presence or absence of these various features will be correlated with the presence or absence of a given pest allergy to support a causal relationship. It is recognized that categorization of the independent variables as a feature of modernization is primarily a subjective process; however, an anthropological presentation of the evolution of the Barbadian domestic environment will elucidate the dynamic features of housing in Barbados and illustrate the fact that Barbadians are achieving a level of development similar to that of industrialized countries such as the U.S..

This chapter presents the general materials and methods relied upon to conduct the study. Following an ethno-historical review of the development of land distribution and housing in Barbadian society (Chapter Three)--which ultimately affects the development of the domestic environment and thus the presence of certain pests--specific

sociodemographic and housing variables will be identified and analyzed in Chapter Four. Chapter Five presents findings from the entomological survey as well as stated behaviors, perceptions and attitudes about household pests. Chapter Six is a presentation of the biomedical testing of allergies to various household pests, including results and discussion, and Chapter Seven concludes this dissertation with a summary of findings and implications for future studies.

The Research Site

Barbados was chosen as the research site for a number of reasons. An important sociodemographic feature was the fact that Barbados is the most heavily populated country in the Western Hemisphere, at over 1500 persons per square mile. Household infestations are a significant problem in densely populated settings (Harwood & James 1979) and also in the tropics (Marchand 1966; Pearson & Cunnington 1973; Dowse et al. 1986; Lan et al. 1988). Because the Barbadian population is almost equally divided between rural and urban residence and because the island is so small--and therefore easily accessible with clearly defined boundaries--Barbados offered a unique opportunity to contrast the incidence of allergy to household pests with crowded urban and rural populations. Another sociodemographic feature was the dynamic status of Barbadian housing. The level of infrastructural development in Barbados and documented

health indicators assured that the epidemiological transition from acute and infectious disease to chronic disease had in fact taken place in Barbados, thus implying the likelihood of a significant incidence of allergy in general and asthma in particular.

The Rising Incidence of Asthma in Barbados

Despite the absence of any recent study on the status of asthma in Barbados, it is unanimous among most Barbadians--health care professionals as well as lay persons--that asthma is on the increase. While exact figures for the incidence of asthma is not known, PAHO reports that the disease category "bronchitis/emphysema/asthma" accounted for a crude death rate (per 100,000 population) of 8.9 in 1988, or 23 persons in Barbados; this figure correlates highly to the U.S. crude death rate of 9.2 for the same category and year (1990). The number of asthmatic attendances at the Accident and Emergency (A&E) Department at Queen Elizabeth Hospital (QEH) doubled within a 10-year period, from 3,503 visits in 1980 to 7,137 visits in 1990 (Figure 2-1). Annually, asthmatic attacks account for more than 13% of all visits to the A&E Department, averaging about 20 patients a day (Naidu 1988, 1990), and make up 12.5% of the Emergency Ambulance Service (EAS) calls (Naidu 1992). A slight decrease in the numbers of visits during 1989 and 1990, at 7,267 and 7,137, respectively, suggested that the dispensing of free asthma

medications and the increase in public awareness and educational programs were possibly stabilizing the incidence of asthmatic attacks (McCarthy 1991a). But a record 7,808 visits in 1991 indicates a continuation in the trend of rising incidence. Nearly half of all asthma-related visits are children under the age of 15 (McCarthy 1991b).

The incidence of asthmatic attacks has a definite seasonal pattern in Barbados. October is the month with the greatest number of visits; Figure 2-2 illustrates the dramatic increase from 1974 to 1991. There were an unprecedented 936 visits in 1988, 899 in 1990, and a record 937 visits in 1991 (Naidu[1], personal communication). Also in 1990, two of the three asthma-related deaths occurred in October (McCarthy 1991c). This corresponds to the rainfall patterns in Barbados, in which the average monthly rainfall peaks in August and October (Depradine et al. 1984). Figures 2-3 and 2-4 illustrate the relationship between asthma visits to the A&E department and monthly rainfall for 1990 and 1991, respectively. Note the unusually large amounts of rainfall for the month of October--and the exceptional amount of rainfall for November, 1991--correlated with the highest numbers of asthmatic visits on a monthly basis.

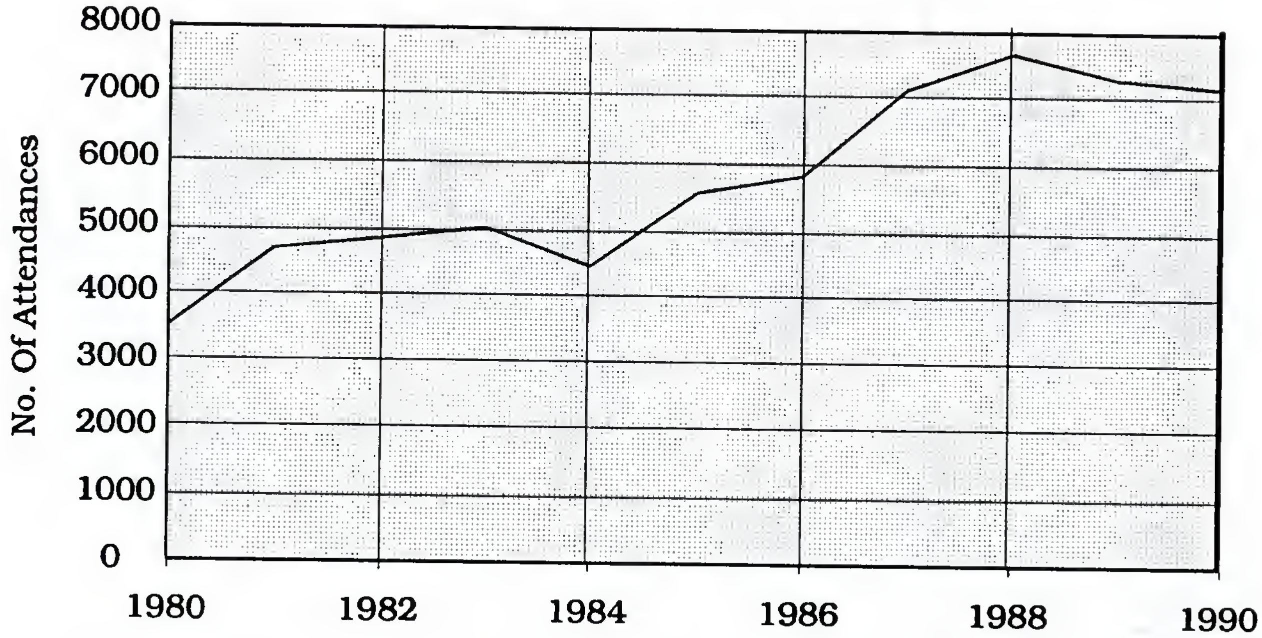


Figure 2-1. Asthmatic Attendances to the Accident & Emergency Department, Queen Elizabeth Hospital, in thousands, for 1980-1990.
Source: Naidu, personal communication.

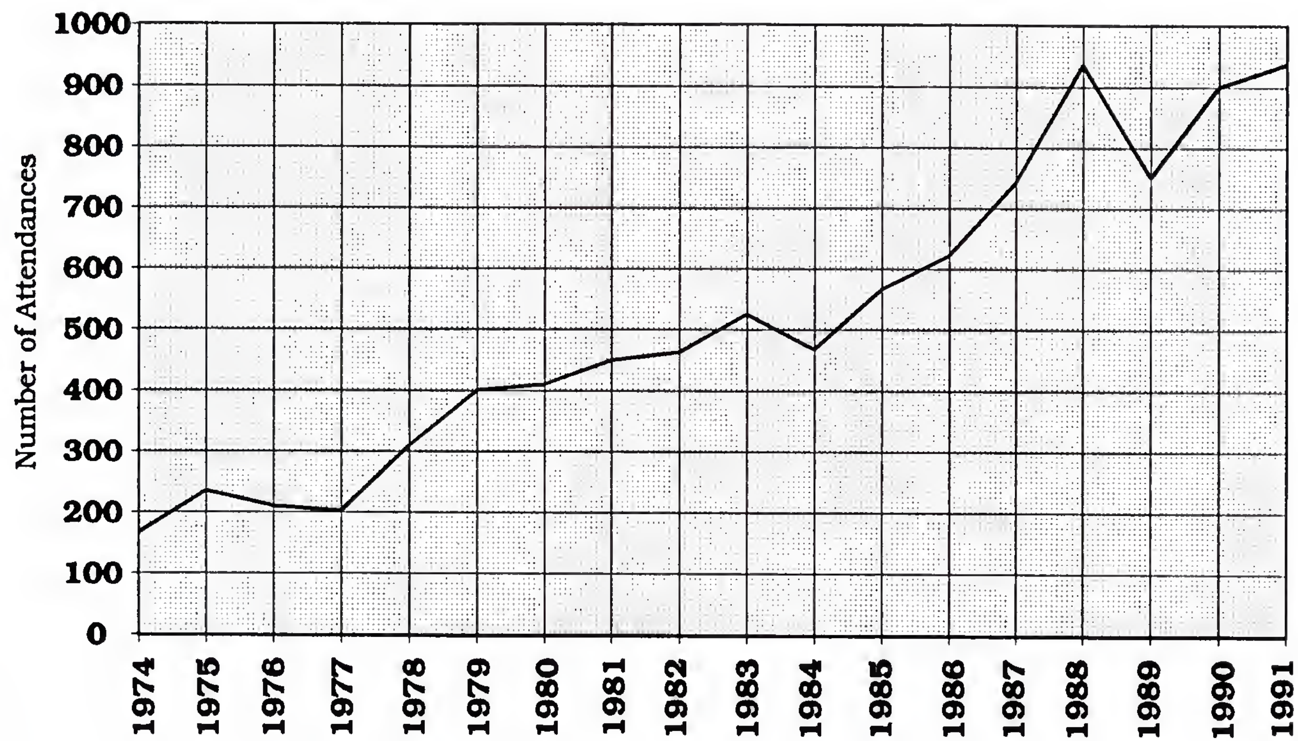


Figure 2-2. Number of asthmatics attending the Accident and Emergency Department, Queen Elizabeth Hospital, for the month of October, 1974-1990.
Source: Naidu, personal communication.

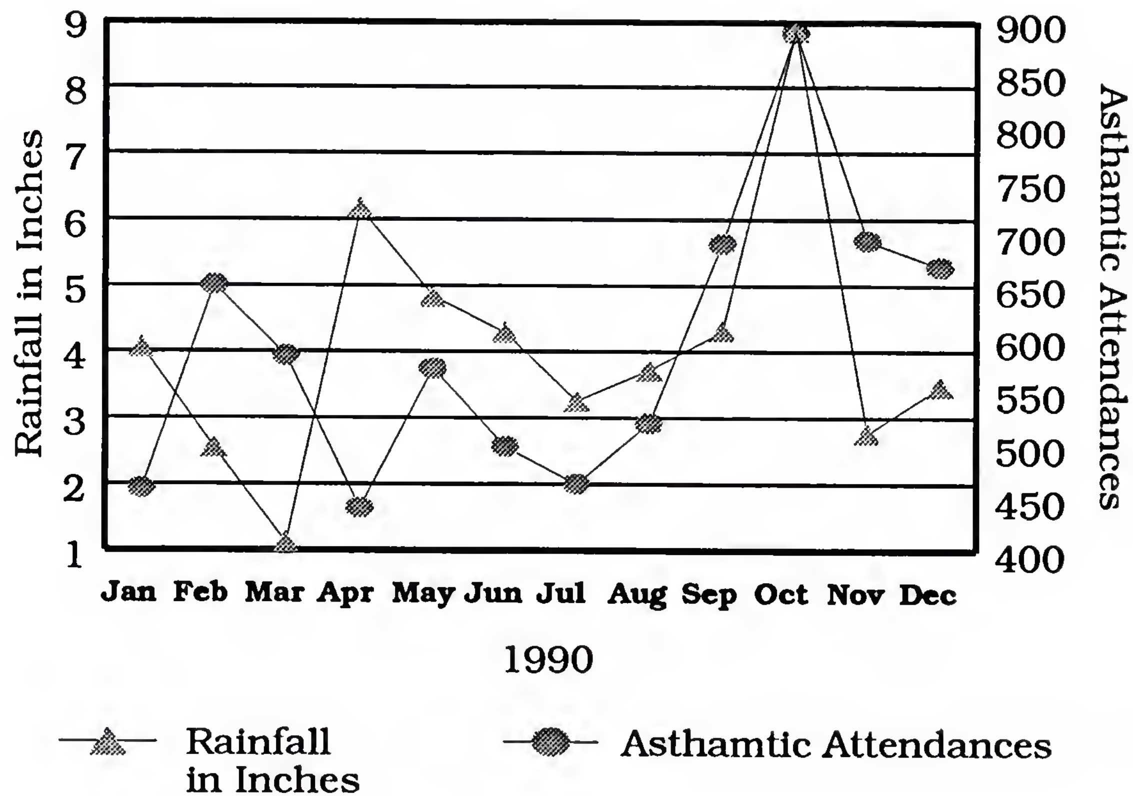


Figure 2-3. Monthly Asthmatic Attendances to the Accident & Emergency Department Compared to Monthly Rainfall, 1990.

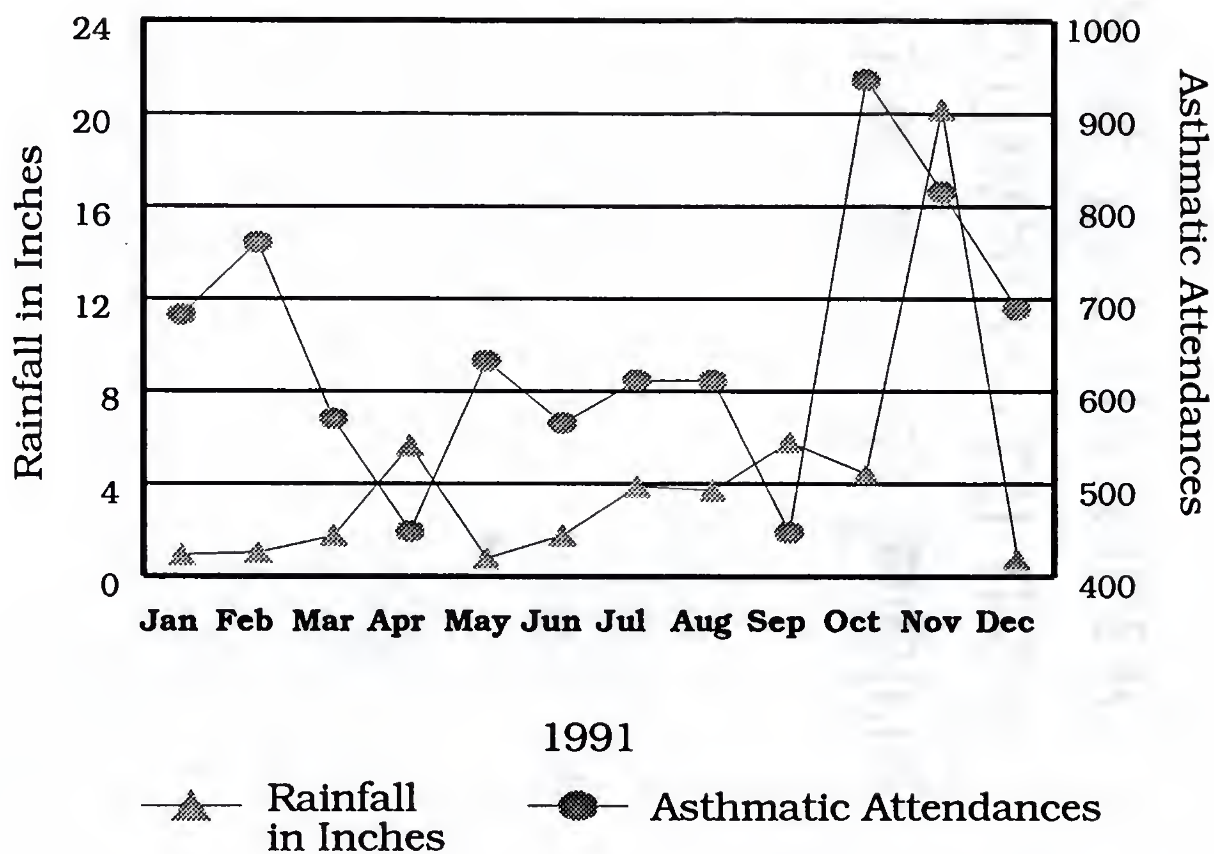


Figure 2-4. Monthly Asthmatic Attendances to the Accident & Emergency Department Compared to Monthly Rainfall, 1991.

The significance of the rising incidence of asthma in Barbados is reflected in the facilities that have been created in recent years to cope specifically with the asthmatic patient. The current Minister of Health, Mr. Branford Taitt, became particularly interested in asthma and health care, due in part to the number of deaths from asthmatic attacks and to the apparently overall increasing incidence of asthma. A policy was instituted in which polyclinics would have nebulizers, peak flow meters, and oxygen available at all times, and asthma drugs would be available in all polyclinic dispensaries. In 1990 the A&E Department was remodeled and included a new "asthma bay" designed especially for asthmatic clients. The bay is situated directly in front of the nursing station, thus allowing full-time observation. An important consideration in understanding the increasing number of hospital visits due to asthmatic attacks is a greater reliance on the A&E Department than in previous years. Naidu suggests that this trend may represent an increasing dependence by the public on the A&E Department as a primary care center for the treatment of asthmatic attacks (1990). It has also been suggested that the decrease in reliance on home remedies and increasing preference for A&E medical treatment is responsible in part for the increase in attendances (Ferdinand[2], personal communication; Naidu, personal communication).

Unfortunately, there are few physicians in Barbados who specialize in asthma disease. One allergist conducts allergy testing and desensitization therapy in his private clinic, but the cost of his services are prohibitive to the average Barbadian. A few physicians, both in the private and public sector, who specialize in internal or respiratory medicine, have earned a reputation as "asthma specialists" and are preferred by asthmatics and parents of asthmatics over polyclinic physicians. In 1990, medications for the treatment of asthma were made free to all asthmatics through the Barbados Drug Service. For the period between October 1989 and December 1990, 5,310 asthma therapy prescriptions were filled at the QEH pharmacy and 7,892 were filled at other government pharmacies, for a total of 13,202 prescriptions (Prescod[3], personal communication). Money spent on asthma medications actually decreased by 4.5% from BDS[4] $261,039 (note: all monetary figures in this thesis will be presented in Barbados dollars, except when indicated otherwise) between July 1988 to June 1989, to $249,435 between July 1989 to June 1990; this factor has been attributed in part to the efficiency of the Drug Service program (Prescod, personal communication).

In June, 1989, the Asthmatic Association of Barbados was founded, following suggestions for the organization during a "national asthma week" seminar provided by the Barbados Drug Service. As of 1991 the organization boasted

some 150 members, most of whom were adult asthmatics or parents of asthmatic children, although the meetings are open to any interested person. The association meets once a month and the primary objective is to disseminate information on the control and management of asthma, usually via a guest speaker[5].

Infrastructure: The Developed Nature of a Developing Country

In 1991 the United Nations revised the human development index and declared Barbados the leading "developing" country among all developing nations (United Nations 1991), a step that Barbadians fear will eventually reduce their eligibility for international aid. The classification is supported in part by an estimated per capita income of US $6,020, higher than the Republic of Korea or oil-rich Venezuela (United Nations 1991). Thus, according to the U.N., Barbados ranks ahead of its neighbors in the Eastern Caribbean in human development; Table 2-1 illustrates the disparity of GNP (gross national product) per capita within the Eastern Caribbean nations.

Barbados health indicators demonstrate a quality of life more comparable to industrialized countries than developing countries (Table 2-2). Great strides have been made in Barbadian health care; between 1920 and 1922, life expectancy was only 31.9 years for women and 28.5 years for

Table 2-1 GNP per capita (1980), in U.S. dollars in the Eastern Caribbean.

Country	GNP per capita
Barbados	6,010
Antigua & Barbuda	3,690
Trinidad & Tobago	3,350
St. Kitts & Nevis	2,630
Grenada	1,720
Dominica	1,680
St. Lucia	1,540
St. Vincent	1,200
Jamaica	1,070

Source: United Nations 1991.

men (Dann 1984). This is in stark contrast to the average of 75 years as of 1990 (United Nations 1991). In a "quality of life" survey, sociologist Graham Dann found that "health" received the highest score of the seven life satisfaction domains (1984), indicating that Barbadians are content with the status of their health and health care delivery. The leading causes of death in Barbados are similar to those of industrialized nations, and include: heart disease, malignant neoplasms, cerebrovascular disease, diabetes mellitus, and "other" circulatory system diseases (PAHO 1990).

Education in Barbados ranks as the leading priority in government spending, at over one fifth of the national budget, or, about $1 per person per day (Dann 1984). Table 2-3 compares educational indicators in Barbados with other Eastern Caribbean countries. As illustrated, there is a 99% literacy rate and education is compulsory for 11 years. It

has been argued that Barbadians are perhaps over-educated for the jobs available, as unemployment for new graduates is higher than in any other age group (Dann 1984). Recently there have been efforts by the Ministry to design a curriculum that would prepare students for the three mainstays in Barbadian economy--tourism, manufacturing, and agriculture, but this move has been sharply criticized by certain nationalists as "encouraging a 'mental attitude of subservience'" (Goddard 1991, p.6).

Barbados was controlled by Britain for some 350 years, and at the time of Independence (1966) the British legal and parliamentary system was adopted. Barbados is classified as an independent, liberal-democratic state with competitive parties, has the highest rating for political and civil rights (according to the Freedom House Index) and a strong emphasis on economic and social reforms (Stone 1985). There is a network of approximately 860 miles of paved roads and public transportation is available in all of the 11 parishes. PAHO (1988) reported 100% coverage of drinking water supplies and sewerage or excreta disposal services in Barbados, which no doubt contributes to the overall good health of the nation. (See Chapter Three for a full description of Barbadian economy).

The Health Care Delivery System

Barbadians enjoy an efficient socialized health care system, reflected by the health indicators previously

illustrated. Government health expenditure per person in 1987 was US $230.58 and the percentage of total government expenditure on health was 13.13 (PAHO 1990). The primary resource centers for receiving health care in Barbados are QEH[6], including the hospital and polyclinics; the distribution of these services is depicted in Figure 2-5.

The concept of polyclinics and public health care came into existence in the mid-1970s. Initially the clinics were serviced by General Practice (GP) doctors who maintained both government and private offices and visited the clinics several times a week. At that time, only patients who passed a "means" test by the welfare department could visit the free clinics or the hospital. In 1985 the government began employing GP's full-time and regular GP sessions commenced in the polyclinics. The "means" test was eliminated and services became available to all residents. While the exact number of persons attending private physicians is not known, 135,810 attendances were recorded in 1990 to the eight public polyclinics and five outstations (see Table 2-4) (Sergeant[7], personal communication). According to R. Naidu, Director of the A&E Department at QEH, the introduction of the polyclinic system has reduced the number of visits to the A&E Department, except in the parish of St. Michael, where there is still a disproportionately high number of attendances when compared to the percent of the population living in that parish

(Naidu 1988). The Barbados Drug Service provides free prescription medications to all persons under the age of 16 years and those over 65 years and to any patient needing medications for venereal disease, cancer, hypertension, diabetes, glaucoma, and, as of 1990, epilepsy and asthma. Dispensaries are available at each of the polyclinics.

Table 2-2. Health indicators for the Eastern Caribbean.

	Life expectancy at birth, in years 1990	Population with access to health services(%) 1985-87	Population with access to safe water (%) 1985-88	Population with access to sanitation (%) 1985-88	Fertility rate 1990	Infant mortality rate per 1,000 live births, 1989
Barbados	75.1	100	100	.	1.8	11
Trinidad & Tobago	71.6	99	96	99	2.8	15
Antigua & Barbuda	72.0	.	100	.	.	22
Dominica	76.0	.	.	.	.	18
Jamaica	73.1	90	72	91	2.5	16
Grenada	71.5	100	.	.	.	34
St.Kitts Nevis	67.5	100	100	100	3.6	.
St. Lucia	70.5	.	67	.	4.2	21
St.Vincent	70.0	.	.	.	.	25
Guyana	64.2	89	61	87	2.6	54

Source: United Nations 1991.

Table 2-3. Profile of education in the Eastern Caribbean.

	Adult literacy rate (%) 1985	Combined primary & secondary enrollment ratio 1986-88	Percent of total public expenditure on education 1988	Compulsory education duration (years) 1988
Barbados	99	11	20.1	11
Trinidad & Tobago	96	6	11.5	6
Antigua & Barbuda	90	11	14.4	11
Dominica	80	10	14.1	10
Jamaica	98	6	11.0	6
Grenada	85	11	12.5	11
St. Kitts & Nevis	80	11	12.5	11
St. Lucia	83	10	16.8	10
St. Vincent	82	.	11.6	.
Guyana	95	8	3.0	8

Source: United Nations 1991, pp.138,146,148.

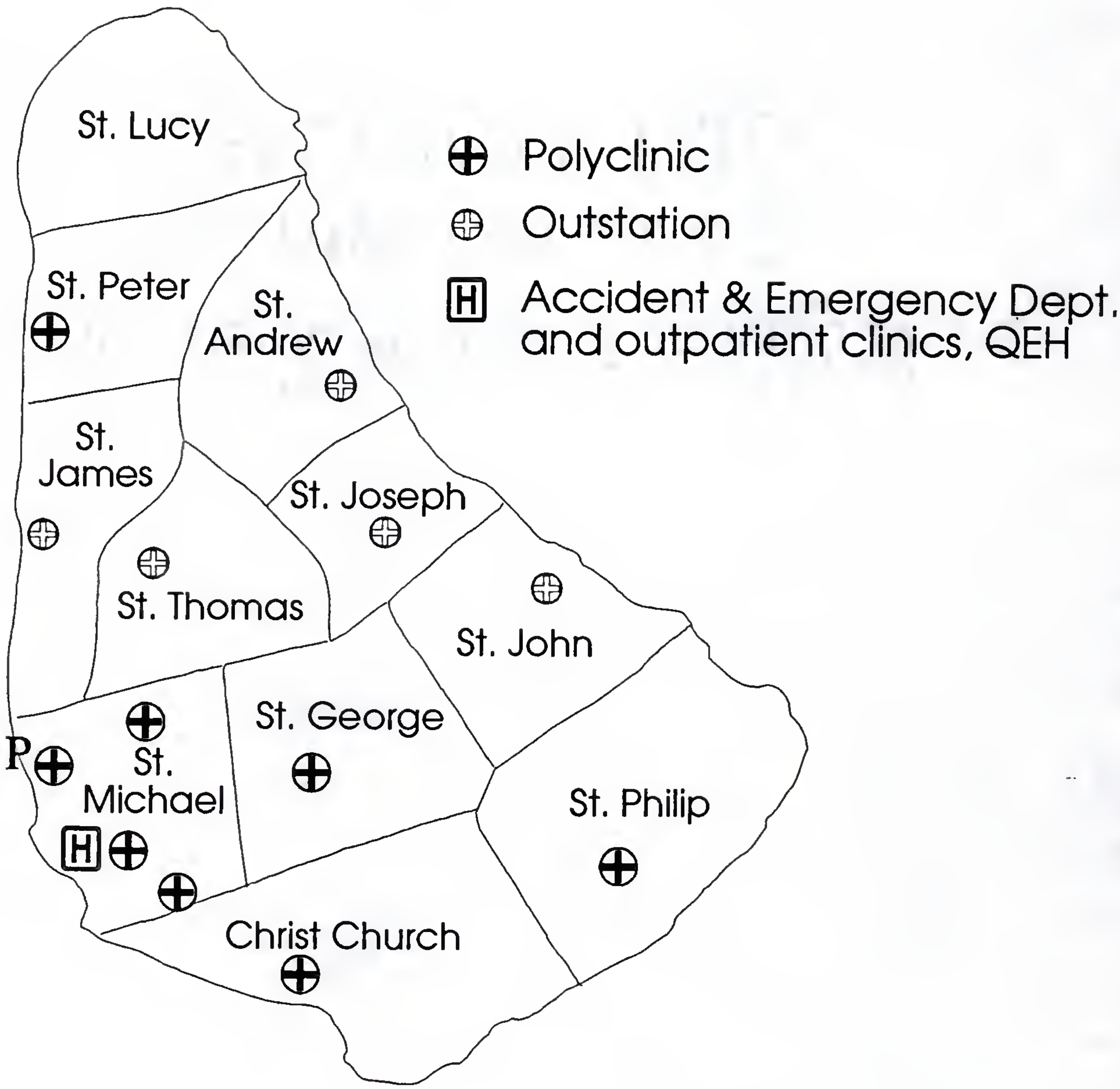


Figure 2-5. Distribution of Outpatient Health Care Facilities in Barbados.

Table 2-4. Polyclinic/outstation attendances, 1990.

Polyclinic	Parish	Total number of patients	Total attendances	Average monthly attendances	Daily range
Edgar Cochrane	St. Michael	4,350	10,865	900	53 - 57
Six Roads	St. Philip	4,113	10,561	880	35 - 50
Gall Hill	St. John	2,548	7,707	642	26 - 34
Maurice Byer	St. Peter	5,981	18,863	1,572	61 - 80
Horse Hill	St. Joseph	774	2,027	169	15 - 27
Warrens	St. Michael	5,545	12,835	1,070	40 - 66
St. Thomas	St. Thomas	697	2,257	188	16 - 28
Belleplaine	St. Andrew	804	2,013	170	17 - 24
Black Rock	St. Michael	9,042	21,491	1,791	74 - 93
Holetown	St. James	437	1,509	126	14 - 23
Randall Phillips	Christ Church	7,544	19,298	1,608	58 - 93
Glebe	St. George	5,105	14,661	1,222	50 - 69
Sir Winston Scott	St. Michael	5,193	11,723	2,099	80 - 111
Total		92,133	135,810	12,442	519 - 755

Source: Sergeant, Ministry of Health, Barbados. 1991. Personal communication.

Sampling and Methodology

The Survey Schedule

The asthma study was conducted in Barbados from January to December, 1991. The project was divided into 2 phases. The principle objectives of Phase I were the following: (1) to qualify the household pest species in the major topographical regions of the island; and (2) to conduct an ethnographic survey, primarily using the techniques of participant observation and informal interviewing, for the purpose of designing an appropriate questionnaire for the study sample in Phase II. These separate operations were conducted simultaneously; while the trapping was taking place in one region, the ethnographic data were collected in the selected households. Three to four weeks were spent at each site during the dry season and two weeks were spent at the sites during the rainy season.

Topographical considerations

Unlike its volcanic neighbors, Barbados is composed of a coral limestone formation, resulting in a relatively flat but terraced landscape, with a series of deep gullies as well as vertical cliffs, the remnants of old coral reefs. The coral limestone base contributes to a good drainage system and a fluctuating but reasonable supply of water, depending on the region, yet negates the presence of rivers or streams. Although there were at one time a number of coastal swamps on the leeward coast, the only remaining

swamp--and the only true body of water on the island at present--is the Graeme Hall Swamp, situated in suburban Christ Church.

The Town and Country Development Planning Office (1988) has divided Barbados into nine topographical areas (Figure 2-6). In the northern cap is the flat St. Lucy Plain (1). Below the First High Cliff area (2) lies almost the entire western beach coast, 20-25 meters (66-82 feet) above sea level. Below the Second Cliff area (3) the region is divided into three sub-regions of terraces. About 35 meters (116 feet) above sea level is St. George's Valley (4), a synclinal structure and relatively small component of the island, and to the east of that lies St. Philip Plain (5), a very flat and poorly drained region. To the north and in the center of the island is the Upland Plateau (6), with dramatic variations of gullies and low terraces to elevations from 130-330 meters (430-1090 feet). An anticline of over 130 meters (430 feet) makes up the southern Christ Church Ridge Unit (7). Finally, there is the Scotland District (8 and 9) in the northeast, the most distinctive of the regions, due to the heavy erosion and subsequent exposure of underlying geological formations consisting of shales, sands, silty clays, and marl (see Town & Country Development Planning Office 1988).

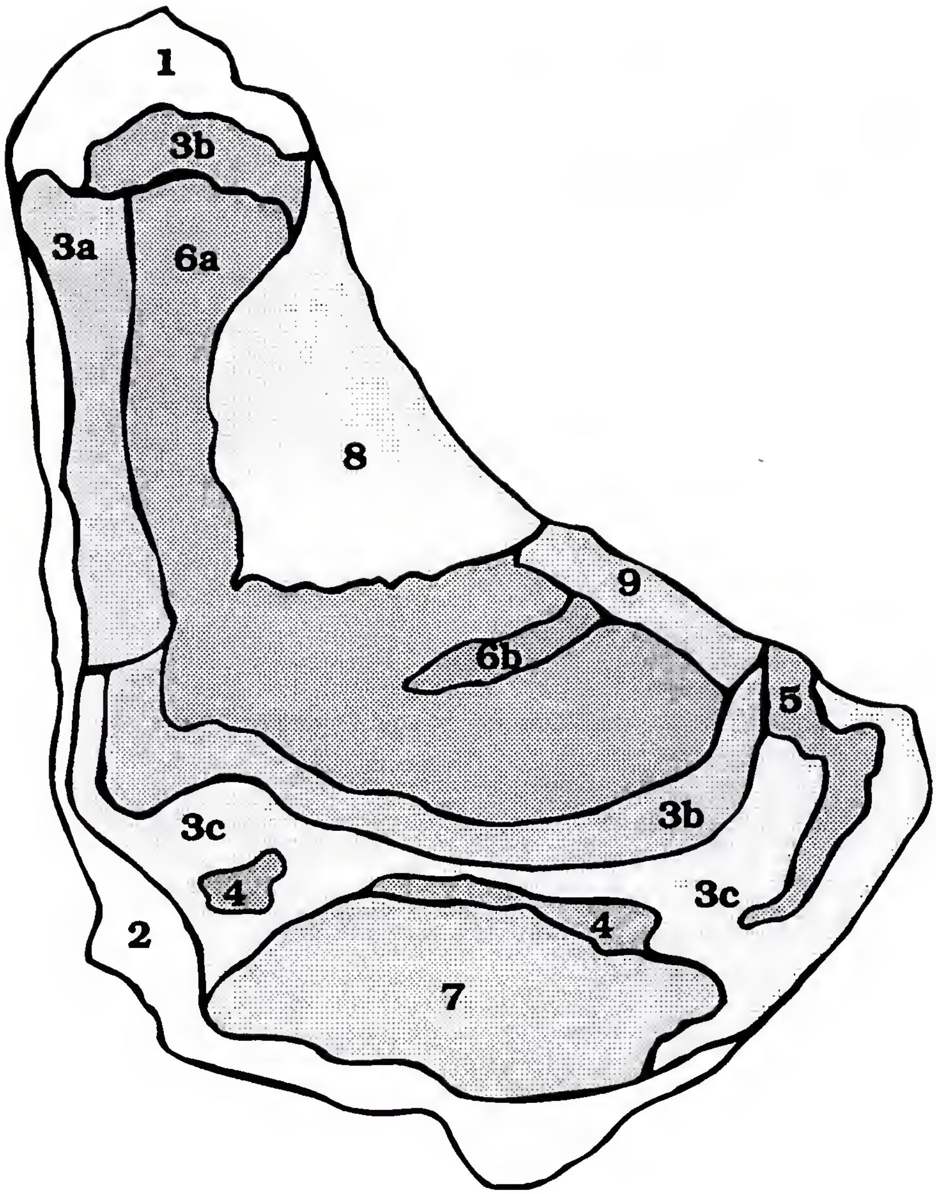


Figure 2-6. Geophysical Subdivisions of Barbados. Numbers correspond to the following regions: (1) St. Lucy Plain, the flat, northern cap of the island; (2) First High Cliff area, below which lies the western beach coast, 20-25 meters (66-82 feet) above sea level; (3) Second Cliff area, divided into three sub-regions of terraces; (4) St. George's Valley, 35 meters (116 feet) above sea level; (5) St. Philip Plain; (6) Upland Plateau, with elevations from 130-330 meters (430-1090 feet); (7) Southern Christ Church Ridge Unit, an anticline of over 130 meters (430 feet); (8) & (9) Scotland District. Figure adapted from map obtained with permission by Town & Country Development Planning Office 1988.

There is significant variation in annual and seasonal rainfall and, because of the terraced structure of the island, rainfall varies considerably from region to region (Figure 2-7). The Barbados Society of Technologists in Agriculture compiled a list of monthly and total rainfall figures in Barbados from 1847 to 1983 and found an annual low of 39 inches in 1947 to a high of 91.5 inches in 1901 and an average annual rainfall of 59.68 inches (1984). Seasonally, however, rainfall averages a low of 1.90 inches in March and over seven inches per month from August to November, during the "rainy season" (Barbados Society of Technologists in Agriculture 1984). Figure 2-7 illustrates the variation of rainfall within the different regions of Barbados, showing the greatest amount of rain falling in the central portions of the island (an average of 80 inches) and the lowest amount in the southern Christ Ridge region and St. Philip (an average of 45 inches) (Plantations Trading Co. Ltd. 1989). Areas with the lowest rainfall correlate with the three areas with the least fertile soil, the west, south, and southeast coasts, and these are also the regions that are the most densely populated (Town & Country Development Planning Office 1988).

It is apparent from the above discussion that, although Barbados is divided into 11 parishes, parish boundaries do not necessarily represent the topographical boundaries. The Leeward side of the island--or West and South coast--is the

most heavily populated and comprises the four major urban centers of Barbados: Speightstown, Holetown, Bridgetown, and Oistins. Within the metropolitan boundaries of Greater Bridgetown live 45% of the national population and the majority of governmental operations and industry. The area between Bridgetown and Speightstown is predominantly devoted to tourism, as resorts line the length of the coastline. Speightstown is a semi-urban fishing town, populated by Barbadians rather than transient tourists. The region south of Bridgetown toward Oistins is also a tourist region, though this area is mixed with residential areas and businesses and is the seat of the main fish market. Recently there has been considerable urban tourist-related growth in a southeasterly direction, encompassing the parish of St. Philip. The major center in this region is Six Roads. Although the eastern portion of Christ Church and the parish of St. Philip are increasingly the focus of growth for industry, the region is still largely agricultural. The northeastern Scotland District is the most sparsely-populated region on the island.

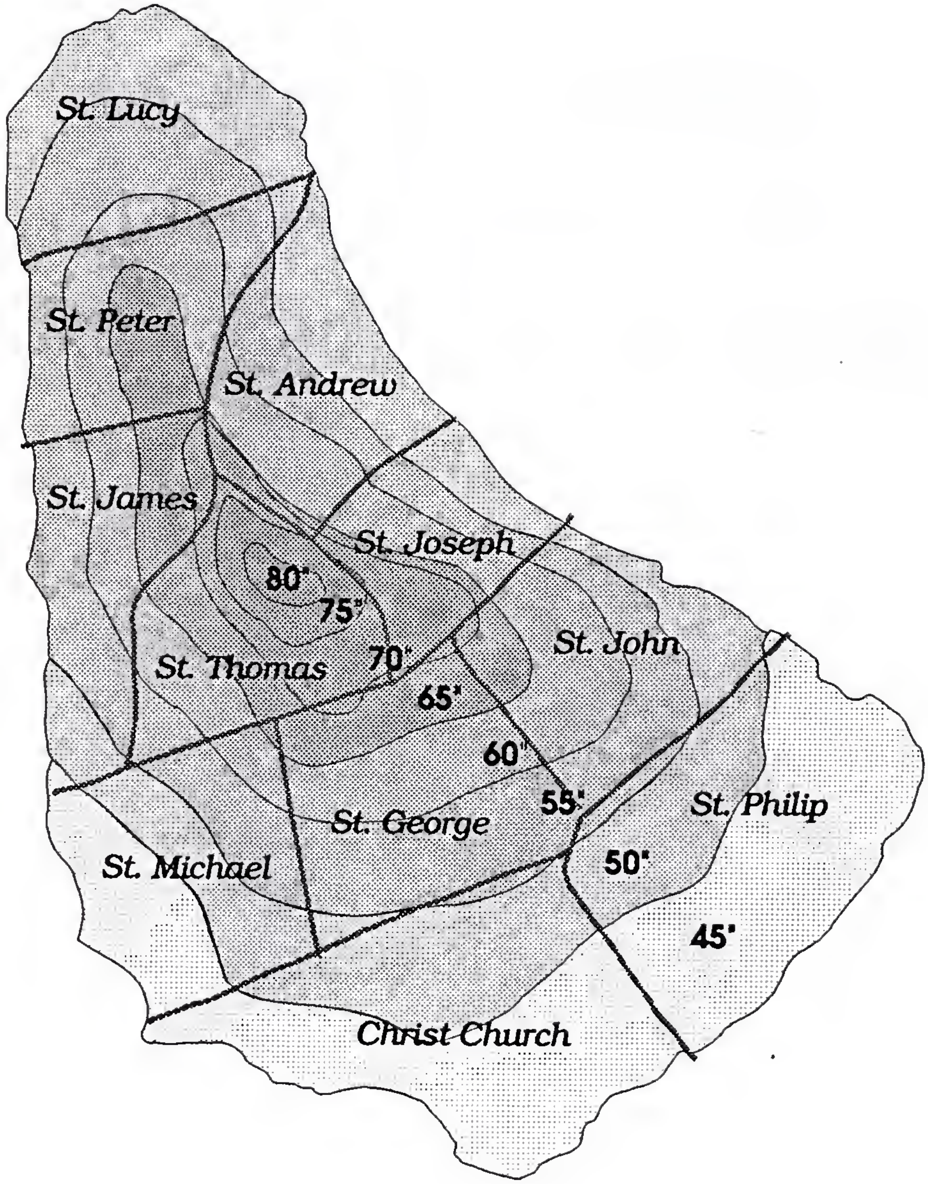


Figure 2-7. Annual total rainfall by region, in inches, based on data from 1887-1986. Compiled by Barbados Society of Technologists in Agriculture. Figure adapted from map obtained with permission by Plantations Trading Company Ltd., 1989.

Selected entomological and ethnographic research sites

After conferring with members of the Ministries of Health and Agriculture, it was decided that five general areas would be systematically selected in order to represent the major topographical regions of Barbados. Villages included the following:

> 1) Chapman Street Village - in the center of Bridgetown, representing the most densely-populated, urban region;
>
> 2) Oistins - Christ Church, representing a semi-urban, coastal population;
>
> 3) Cotton Vale - a rural tenantry, north of Six Roads, representing the St. Philip Plain and agricultural sector;
>
> 4) Chalky Mount - another rural tenantry, but situated in the northeast Scotland District of St. Andrew;
>
> 5) Rose Hill - a semi-urban village, below the Second Cliff area, just south of the St. Lucy Plain and north of Speightstown, St. Peter.

Once a village was selected, the houses were mapped, numbered, and listed. From that list four homes were randomly selected. The adult present at the time of the visit was asked to participate in the study. If a consenting adult was not home, two subsequent visits were made in an effort to include the household in the study. If after the third visit no adult was home, or if that adult declined to participate, another house was randomly selected. This continued until four households in each of

the five villages agreed to participate. Figure 2-8 depicts the location of the five sites for Phase I.

Entomological samples were collected during both the "dry" season (January-May) and the "wet" season (September-December). The methods and materials are presented in Chapter Five, after which the results and discussion of trapping are addressed.

Participant Selection and Resources

In order to select the sample population for the biomedical testing, the following persons were consulted: the acting Chief Medical Officer, a Ministry of Health epidemiologist, Medical Directors of six polyclinics, the Director of the A&E Department at QEH, a Respiratory Medicine Specialist at QEH, and a private Internal Medicine physician in St. Michael. With the assistance of these persons, three major health care resource centers were selected for choosing the sample population and included the following:

1) five polyclinics and one outstation, the total of which serviced patients from all regions of the island;

2) a private practice clinic, situated in the urban district of Greater Bridgetown and servicing patients from all of the 11 parishes;

3) and the A&E Department at QEH, servicing the entire Barbados population.

Figure 2-9 illustrates the resource centers used for selecting the sample population. Notice that two of the

polyclinics selected were located in the parish of St. Michael to account for the large proportion of the population living in that parish, and two of the other polyclinics--Sir Randall Phillip and Maurice Byer--were located in the urban "belt", in the major towns of Speightstown and Oistins, respectively. Maurice Byer services patients from the northern region of the west coast, north of Holetown, the northern cap of St. Lucy, and the northeastern Scotland District. The remaining rural residents in the southern Scotland District region are serviced in part by the Gall Hill outstation in St. John. The private physician's clientele were mixed; many were from the lower socioeconomic strata, who preferred to use a private physician rather than a polyclinic and others were middle- and upper-income clients, many of whom lived in the suburban terraces and heights[8].

Three-hundred and fifty children between the ages of five and 18 years were systematically selected from the health care centers. Each asthmatic patient attending one of the selected clinics was asked to participate until a total of 175 asthmatics was obtained; in the event that the parent/guardian agreed to participate, the next non-asthmatic child attending the clinic that matched the asthmatic by age and sex was selected, until 175 controls were obtained. Because of the systematic selection process, if the patient to be seen was accompanied by siblings or

relatives, asthmatic or non-asthmatic, the other children were asked to participate as well. The only exclusion criteria was that the child must either be an asthmatic or non-asthmatic; other types of atopics were not included (e.g., hay fever). Selection of asthmatics was based on a positive history and physical examination and criteria included previous attacks, diagnoses and treatment for asthma. The history and physical are the primary means for diagnosis of asthma in Barbados; diagnostic tests such as serum titers, bronchial challenge tests, and skin tests are not practiced routinely, largely due to prohibitive costs. A "selection criteria" form was designed, approved by the acting Chief Medical Officer, and completed for each child (asthmatic and control) to confirm or eliminate a diagnosis of asthma.

At the time of selection the parent/guardian of the child read and signed a written informed consent and was assigned an appointment for the allergy testing at one of the six chosen polyclinics. The parent/guardian was asked to choose the polyclinic that was closest to the child's home and instructed to withhold antihistamines, ephedrine, or asthma medications 24 hours prior to the testing. In the event that medications had to be administered, the appointment was rescheduled. Parents were reminded of the appointment by telephone 24-48 hours before the test. If

that household did not have a telephone, the nearest relative or neighbor with a telephone was contacted.

Clinical Testing and the Interview Schedule

The allergy test included skin testing (scratch and intradermal) to various household pests (note: details of the skin test procedure are described in Chapter Six). Controls did not undergo the skin test due to the difficulty in recruiting non-asthmatic participants for this aspect of the testing; the skin test involved a battery of 11 extracts, requiring a minimum of 11 scratches and potentially 11 injections. Receiving no personal benefit from undergoing this procedure, parents and non-asthmatic children were unlikely to volunteer as controls and it was deemed unethical to subject them to the procedure. To assure validity of the test within the asthmatic population, a negative control was used in both the scratch and intradermal test. Exclusion of non-asthmatics from the skin testing procedure was further substantiated by the overall objective of the study, which was to determine which features of the domestic environment were contributing to the likelihood of asthmatics developing allergies to certain pest species.

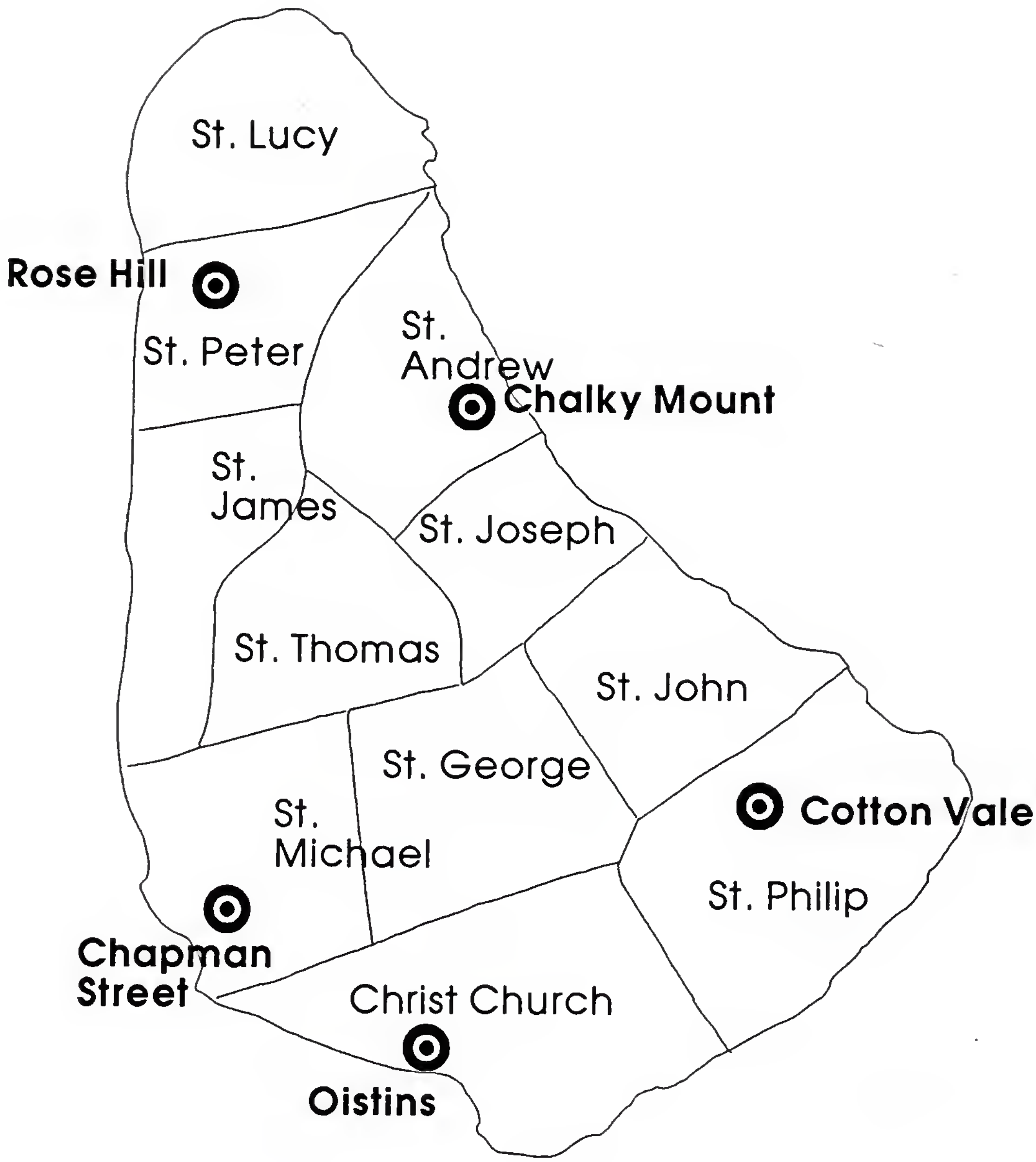


Figure 2-8. Location of selected communities for the entomological and ethnographic surveys.

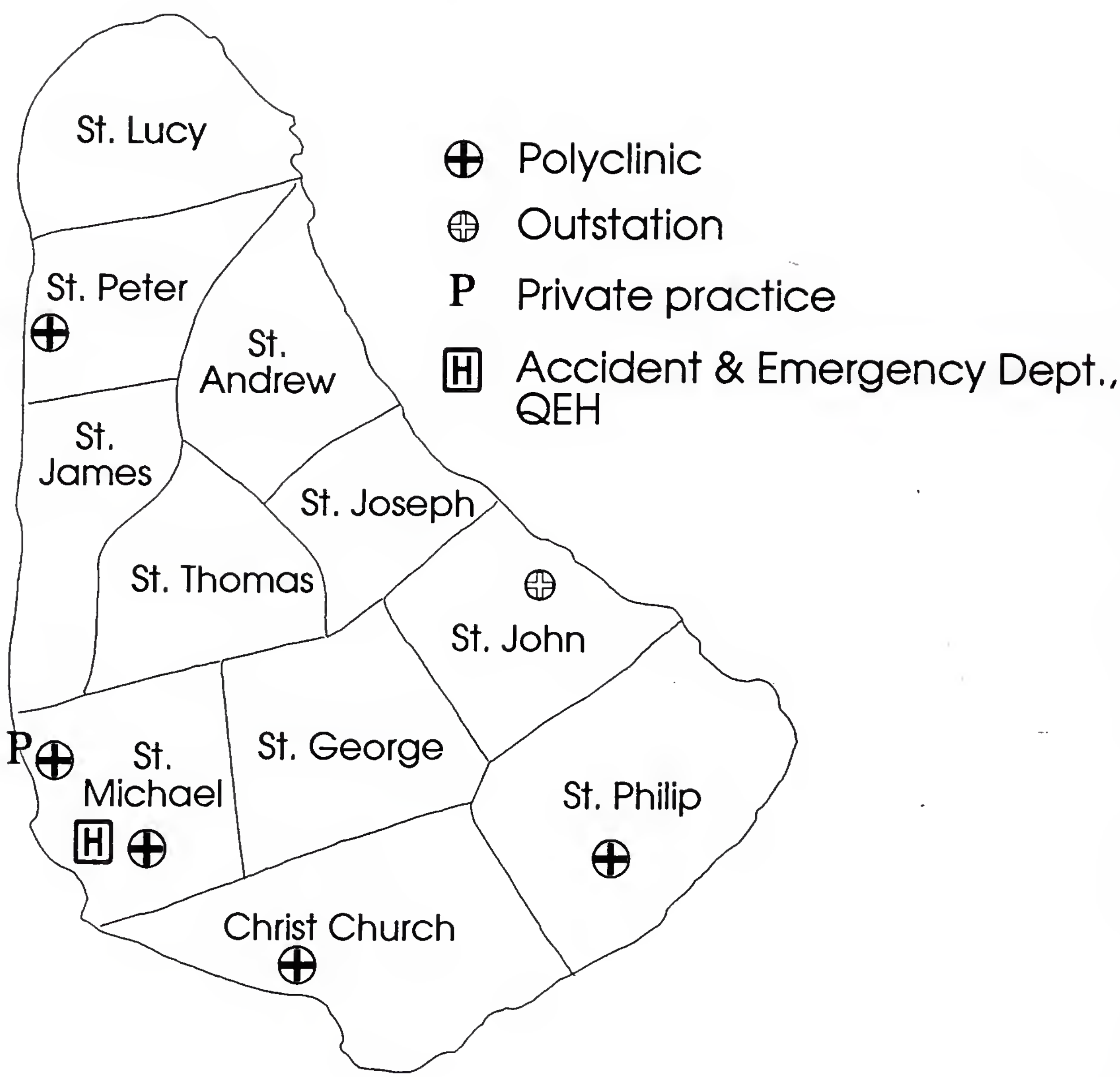


Figure 2-9. Resource centers for the asthma study sample population.

The questionnaire, designed from ethnographic data collected during Phase I, was pre-tested on a randomly selected population (N=10) prior to operationalizing Phase II and included informants who were parents of asthmatic (N=5) and non-asthmatic children (N=5) from the five villages in which Phase I was conducted, but not from the same households. The questionnaire was revised and pre-tested again on another randomly selected population (N=10), equally divided between parents of asthmatic and non-asthmatic children and also from the five villages.

Following the pre-testing phase, the final questionnaire was divided into two sections so as to minimize the risk of informant fatigue and annoyance during the interview. The first section was administered in the clinic prior to the allergy testing and serum collection. An appointment was made in the clinic for a home visit so that the second section of the questionnaire could be administered. In the event that a home visit was not possible due to time constraints, a telephone interview was conducted.

The questionnaire included three general topics: sociodemographic information on the child's residence and structural information on the dwelling; the informant's perceptions, knowledge, and behavior associated with health and illness in general and asthma in particular; and the

informant's perceptions, knowledge, and behavior associated with household pests and pest-related disease.

Sub-Setting the Sample Population

As described, the overall objective of the study was to determine the relationship between sociodemographic and architectural independent variables with the dependent variable, hypersensitivity to individual household pests. Seven asthmatic children and eight controls were eliminated from the study after the trials and interviews because either their classification of "asthmatic" or "control" was questionable, or a follow-up interview could not be administered. The group of asthmatic children who underwent skin tests to determine the pests to which they were allergic comprised the "asthma population" (N=168). Controls (N=167) were used to compare informant responses regarding perceptions, knowledge, and behavior related to health care and asthma. The combination of asthmatics and controls made up the total "study population" (N=335).

To conduct bivariate analyses on the sociodemographic and structural variables and to construct a socioeconomic index to be included in these bivariate analyses, it was necessary to reduce the total study population to the household level. The rationale for this breakdown is the fact that 72 informants had more than one child in the study; therefore, the weight of that informant's response would be greater than that of an informant with only one

child in the study, resulting in a "pseudoreplication" of responses and misleading correlations.

Consequently, one child from each household was selected randomly from the total population, regardless of his/her classification as asthmatic or control, using the Q&A database program (Symantec Corp. 1991), and data on that child and his/her household was entered into a subset referred to as the "household sample". The total household sample size was 177 (after disqualification of cases with insufficient or ambiguous data). Bivariate analyses on all of the independent variables were first administered on this sample population to identify correlations and selection of the appropriate independent variables that would later be analyzed for the asthma population.

Identifying and Classifying the Independent Variables

The word "modernization" connotes the up-grading of standard of living at both the population and the household level. Standard of living at the population level is typically measured by socioeconomic indices such as per capita income, quality of housing, and quality of life factors, including health. In this respect, Barbados fares well according to U.N. standards.

Standard of living at the household level may vary tremendously within a population and can be used to represent the degree of class disparity in a given society. While Barbados enjoys a high standard of living compared to

other developing countries, in no way is Barbados a "classless society", as there clearly exists a significant degree of class consciousness and stratification (Dann 1984; Potter 1983a,1986). For example, nearly a quarter of the population lived below the poverty line between 1980 and 1988 (United Nations 1991). In order to classify respondents according to socioeconomic status, an attempt was made to create a socioeconomic index variable.

Designing a Socioeconomic Indicator

Graham Dann, a Barbadian sociologist, conducted a study entitled "The Quality of Life in Barbados" (1984), in which he addressed a number of socioeconomic and sociodemographic issues in contemporary Barbados. He discussed the weakness of most studies in the Caribbean prior to his own study, in that the classification of socioeconomic status was usually based on a single indicator, such as income or occupation, thus failing to recognize "...that social class is multi-faceted" (1984, p.30). In response, Dann constructed a six-item index for measuring socioeconomic status among his sample population, which included the following: (1) social mobility (based on the improvement of residential location and real income); (2) income group (reported monthly income, grouped into quintiles); (3) occupation (5 categories, in ascending levels of skill); (4) home ownership; (5) amenities, (household possessions); and (6) education (primary, secondary, and tertiary). Dann's index was

integrated into the asthma study questionnaire, but during the analytical phase of the project, certain weaknesses were realized regarding the application of this scale to the asthma study.

<u>Income</u>

Reported income as a measure of socioeconomic status in the Caribbean is unreliable for several reasons. One problem is the predominance of a working class, which is quite different than that seen in industrialized countries (Dann 1984). Particularly in Barbados, credence must be given to the importance of remittance as income secondary to large-scale emigration (Roberts 1955; Cumper 1959; Ebanks et al. 1979). Other influencing factors in household income--and often undermined--are contributions from the informal sector, underemployment, and the seasonality of jobs. For example, Dann (1984) reported that, of the 6,900 - 7,000 laborers in the sugar industry, 2,500 - 3,500 were seasonal crop workers.

Not surprisingly, and probably due to a combination of these factors and others, failure to report combined family income was relatively frequent in the asthma study population; 17 informants (9.6%) gave no information whatsoever when asked what the monthly income was for the household. Twenty-eight informants (16%) stated that she/he had "no idea" what the entire household earned on a monthly basis and could only report her/his own or one or more

family members' income, but not the entire household. Thus, only 132 informants out of 177 (75%) reported what they believed to be a combined monthly income for the household.

In this particular study, informant inaccuracy was compounded by another complication, but historical in nature. The year 1991 was one of the most turbulent in Barbadian history at the econo-political level, as the unstable world economy, inflation, and the alleged financial mismanagement in the public sector resulted in a seemingly irreparable debt crisis, necessitating the request for a loan from the International Monetary Fund. The subsequent Letter of Intent mandated a number of economic reforms, such as civil pay cuts, job cuts, inflation, and threats of devaluation, sometimes resulting in dramatic changes in household income during the period of July to December, precisely when Phase II of the asthma study was being implemented[7].

Occupation

Dann (1984) included type of work, or "occupation", in his social index. He classified occupation according to the type (unskilled manual, skilled manual, white collar, and professional/managerial). Similar to the problem of reported income, a weakness in relying on occupation as a measure of socioeconomic status is the relatively high frequency of underreporting in the informal sector (e.g., cottage industry) and the seasonality of certain jobs.

Therefore, it was decided not to rely upon this variable in the socioeconomic index. Underreporting of occupation was in fact empirically evident in the study. In one case, an informant reported that her husband was employed as a postman. During the home visit, the author noted that the informant's husband, after changing out of his postal uniform, apologized for not being "more sociable", but he needed to "get to work at [his] second job", as a seamster, in the adjacent room. The informant had only reported that her husband was a postal worker; the informal job, and no doubt a significant contribution to their monthly income, was not reported.

In other cases, informants appeared embarrassed to report employment that was not traditionally "formal." For example, it was not discovered until the home interview that an informant's brother was a jet skier who sold jet ski rides to tourists; he had been classified as unemployed by the informant in the clinic. Remittances as a form of household income were never documented on the questionnaire, but were sometimes revealed during casual conversation with an informant.

<u>Amenities</u>

The degree to which people spend their money on nonessential household items reflects the amount of "extra" income available to the household. Tallman & Ihinger-Tallman (1979) concluded that people living in developing

countries that have reached an advanced stage of modernization tend to focus on material attainment more than their less developed counterparts. Comparing families in four rural Mexican villages to blue collar Mexican urbanites, the following was noted: "...whereas the village children sought primarily to make as much money as they could, the Michoacan urban children sought high status jobs and the opportunity to spend the money they earned on consumption items" (1979, p.231). Further, persons living in developed societies focus less on material gains altogether than they do on fostering interpersonal relations (Tallman & Ihinger-Tallman 1979). It was believed that Tallman and Ihinger-Tallman's study applied, to a degree, to the Barbadian population and "amenities" was considered in the index.

Dann (1984) included "material possessions" in his socioeconomic index by creating a 10-item Guttman scale. Items were arranged in order of decreasing popularity. Dann found statistically significant correlations between "consumer durables" and occupation, income, and social class and concluded that material possessions were highly associated with Barbadian social standing (1984). After completing the participant observation phase of the asthma study, Dann's amenities list was adjusted slightly and incorporated into the questionnaire and included 22 different items.

A bivariate analysis was performed on all of the items to determine which amenities were strongly related to each other. Amenities that were correlated to only a few other items, or weakly correlated to most items, were discarded. Frequency distributions were calculated for the remaining nine items, and these items were then arranged in order of declining popularity. Table 2-5 illustrates the number of households that owned one or more of each amenity item.

Table 2-5. Frequency distribution of amenities by household (N=177).

Amenities	Number of households owning at least one	Percentage distribution of amenities for total
TV (color/black & white)	167	94.4
Radio	165	93.2
Refrigerator	160	90.4
Telephone	135	76.3
Clock	114	64.4
Automobile	54	30.5
Washing machine	42	23.7
Solar heating	20	11.3
Burglar proofing	9	5.1

After determining the frequency distribution of the nine amenities, the items were weighted according to their order, creating a nine-item Guttman scale, then totaled. The result was a potential range of zero (in which case the informant had none of the items) to 45 (the informant owned all nine items).

<u>Monthly expenses</u>

In addition to household income, informants were asked to calculate monthly "cost of living" expenses, which included the following list of 20 estimated expenditures per month:

- water
- electricity
- telephone
- bottled gas
- other gas
- furniture - high purchase/credit[8]
- appliances - high purchase/credit
- other high purchase/credit
- cable/satellite television
- bus fares
- car/motorbike expenses (gas, insurance)
- food
- land rent
- house rent/mortgage
- domestic labor
- child's educational expenses
- medical expenses (visits, prescription medications, non-prescription medications)
- pest control service
- rat/mice baits/poisons
- insecticides, sprays, coils, vape mat (mosquito control), baits

The sum of this list equaled the "total monthly expenses" variable and ranged from $165 per month to $3,196 per month. The "total monthly expenses" figure was assumed to be the minimal monthly expenditure for the household and therefore the minimal monthly income required to support these expenses. A frequency distribution was plotted and divided into quintiles (Table 2-6).

"House-related" variables

Because the primary objective of this study was to determine which independent variables associated with modernization of the home were most important in predicting the development of allergy to household pests, it was not possible to include any factors

Table 2-6. Distribution of total monthly expenses in the household sample (N=177).

Expense range ($ per month)	Frequency	Percent
165 - 569	33	18.6
581 - 789	37	20.9
812 - 1,040	36	20.3
1,043 - 1,276	35	19.8
1,295 - 3,196	36	20.3

associated with the house in a socioeconomic index. This included variables of structure, ownership patterns, household density, and geographical location (urban/rural). Each of the following "house-related" variables were identified as separate independent variables and correlated against each other and against selected socioeconomic and sociodemographic variables. The variables include the following:

1. geographical location (urban/rural)
2. parish
3. demographic region
4. home ownership
5. land ownership
6. building material for the foundation of the house
7. building material for the walls of the house
8. presence of a crawl space under the house
9. proportion of a finished ceiling
10. presence of carpeting
11. number of windows
12. number of rooms in the house
13. presence of an indoor toilet
14. presence of an indoor shower
15. total number of indoor water taps
16. ratio of total number of occupants by the total number of bedrooms
17. age of the home

The results of the bivariate analyses for "house-related" variables are presented in Chapter Four.

Creating the wealth index

Having eliminated all possible variables except for amenities and total monthly expenses for the purpose of creating a wealth index similar to that presented by Dann (1984), a bivariate analysis was performed on these two remaining variables. While a correlation coefficient gave a statistically significant outcome (r=0.38, p=0.05), a general linear model (GLM, SAS Institute 1988) indicated that only the fifth quintiles of the "total monthly expenses" distribution differed significantly (Tukeys means separation) from all other quintiles when compared to "amenities."

In order to identify the most predictive elements of the "monthly expenses" variable, a bivariate analysis was

conducted for each expenditure on the list of monthly expenses by the amenities score and by each of the "monthly expenses" variables. No single variable for "monthly expenses" was consistently predictive (at the p=0.05 level); however, relatively high correlation coefficients were evident for a few of the variables. These correlations were not appropriate because they were strongly influenced by only a few high values, and when they were tested by "TableCurve" (Jandel Scientific 1991) the best fit equations exhibited such low r^2 values that the variables were deemed predictive for only a few observations and not for the entire population.

Although the variable "monthly house rent/mortgage" had a very low correlation coefficient, when all of the "expense" variables were viewed on a scatterplot against the variable "amenities", the best relationship over the range of amenities was "house rent/mortgage." This relationship was then modeled using a nonlinear regression analysis (TableCurve v3.10) (Jandel Scientific 1991). Figure 2-10 illustrates the analysis. The model only accounted for 33% of the variability and again, only reflected those observations at the high end of the "amenities" score.

In conclusion, it was decided that a wealth index could not be created for the asthma study sample by collapsing any of the traditional socioeconomic variables into one index. The only "monetary" variable used in the study was

"amenities", although construction materials (e.g., concrete) are, indirectly, representations of both social and financial status in Barbados and therefore a very strong indicator of wealth. Failure to delineate participants into "class" reduces the risk of imposing subjective values upon the construct of "modernization", recognizing modernization as a process rather than an achievement. Having exhausted a number of methods of analysis on all of the income-related variables, it was concluded that households could objectively be classified according to socioeconomic status based on "amenities." Consistency of the "amenities" variable is evident (mean=16.6, median=15, mode=15). "Amenities" was correlated with a number of sociodemographic indices, including the following: gender (higher scores associated with male informants) ($t=2.33$; $df=175.0$, equal variance; $p=0.02$), age (higher scores associated with older informants) ($r=0.21$, $p=0.005$), and education (higher scores associated with a higher degree of education) ($f=4.59$; $df=2, 174$; $p=0.01$). The variable was also weakly correlated to the percent of employable adults in the household currently employed ($r=0.13$, $p=0.07$).

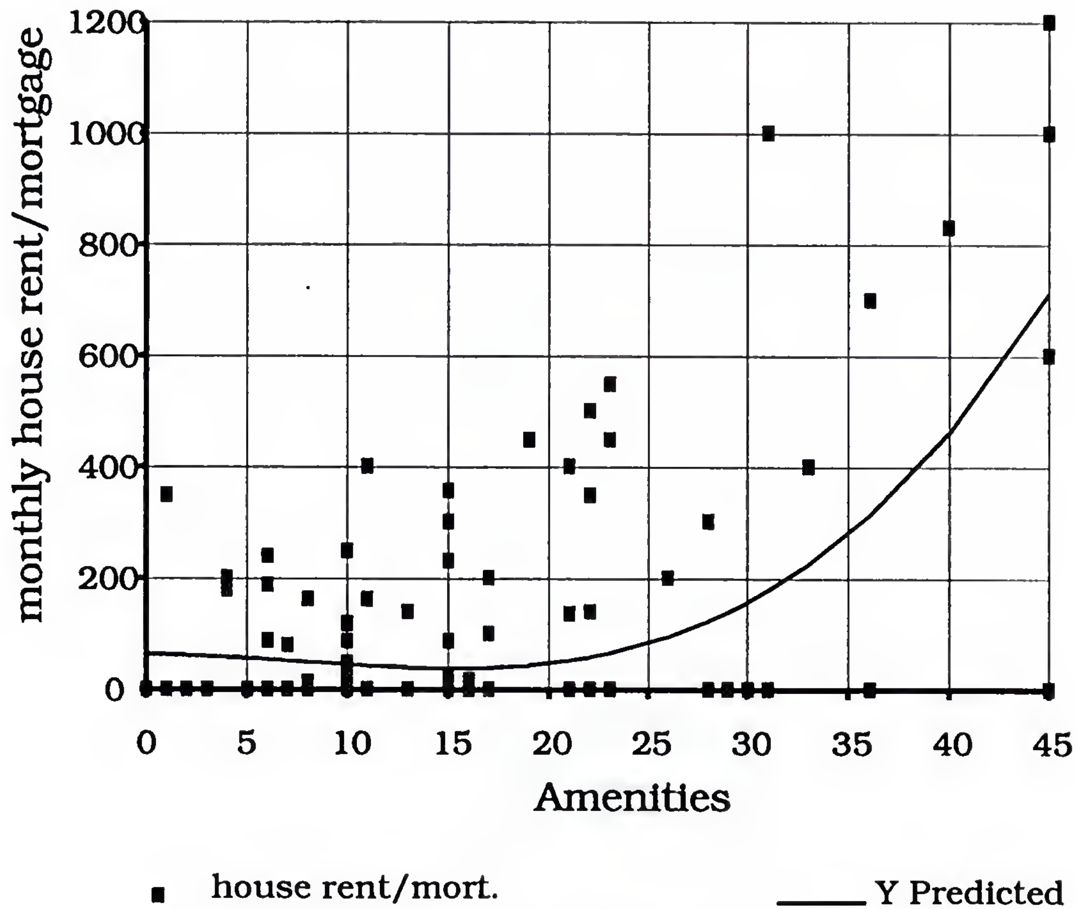


Figure 2-10. Non-linear regression analysis demonstrating the relationship between the variables "monthly house rent/mortgage" and "amenities." The model equation of $y=63.148-0.328xy+.014x^3$ has a coefficient value of $r^2=0.34$.

Demographic Characteristics of the Sample Population

Spatial Distribution

Ninety-six (54.2%) informants lived in the urban sector and 81 (45.8%) lived in the rural sector. Figure 2-11 depicts the distribution of households by parish, demonstrating an under-representation in the very rural parishes of St. Andrew and St. Joseph at 2% and 1.7%, respectively, but an overall representation of the rural parishes of St. Lucy, St. Andrew, St. Joseph, and St. John at 21%. A combined rural population of nearly 46% is, in fact, higher than the national estimated 38% rural sector based on data from the Town and Country Development Planning Office (1988), and conversely, the 54.2% urban population is less than the estimated 62% urban sector. A closer examination of breakdown by demographic region is illustrated in Table 2-7.

Table 2-7. Distribution of residences by demographic region (N=177).

Region	Frequency	Percent
Densely populated (within 2 miles of Bridgetown)	44	24.9
Semi-urban	39	22.0
Peri-urban (in urban district, visible agriculture)	11	6.2
Suburban height/terrace	5	2.8
Rural tenantry	75	42.4
Government housing, rural	1	0.6
Mixed rural (tenantry/NHC)	2	1.1
Total	177	100.0

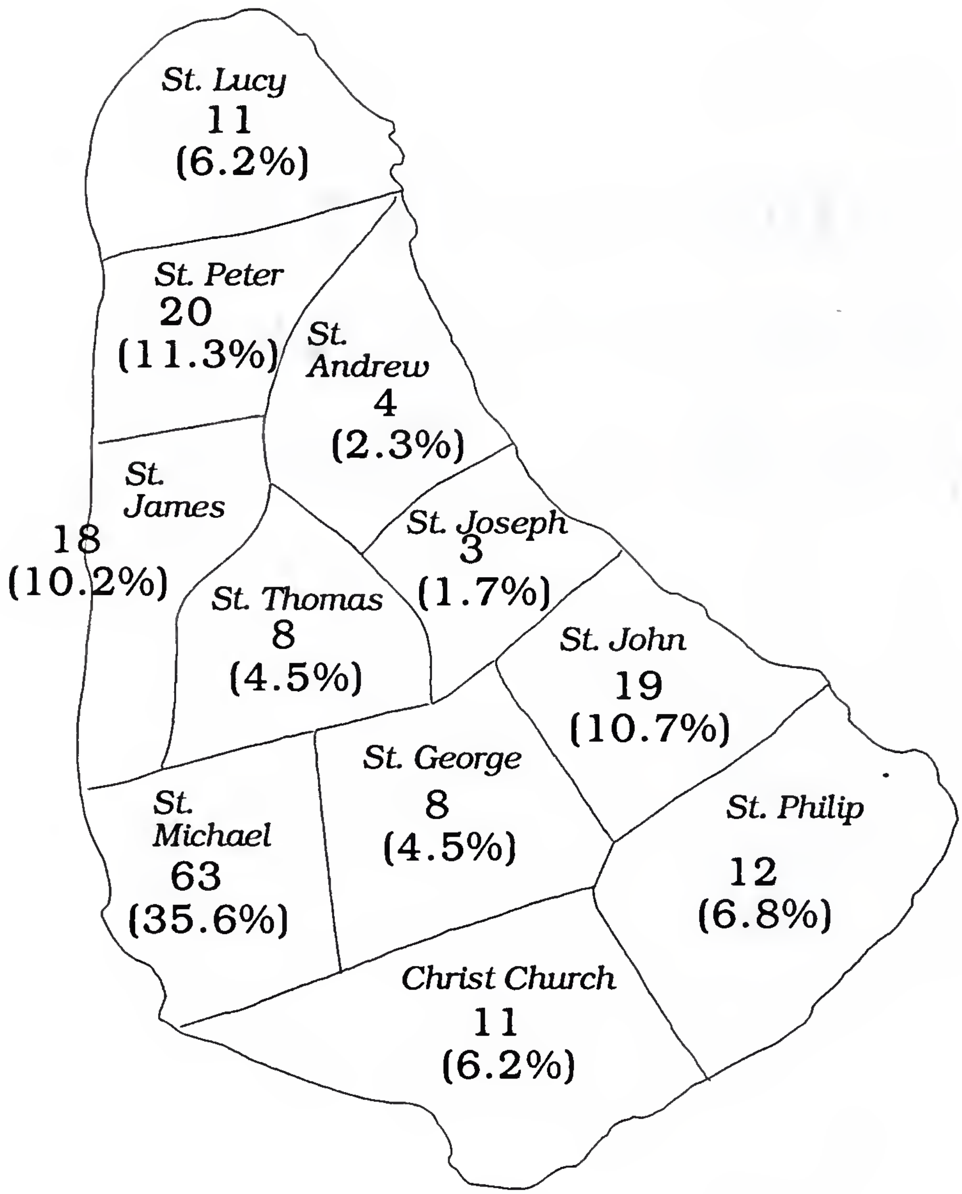


Figure 2-11. Spatial distribution of households by parish, for the asthma study population.

For the total population, 55.4% of the asthmatics were urban compared to 51.5% urban controls. Table 2-8 depicts the spatial distribution of the total population. The majority of the children were chosen from the polyclinics (N=263), (59.5% of the asthmatics and 97.6% of the controls). Fifty-seven (34.0%) of the asthmatics and four (2.4%) of the controls were chosen through the private physician's office, and only 11 (6.5%) of the asthmatics and no controls were selected from the A&E Department. There are several reasons for the heavy concentration of controls selected from the polyclinics. By virtue of the volume of children seen each day in the polyclinic, the opportunity was greatest there for asking persons to participate. Secondly, the private physician and the A&E Department director both felt it was unethical to do more than mention the study to potential controls at other health facilities, because the patient and parent/guardian had exerted a special effort to attend these clinics for specific health care needs and were usually preoccupied with resolving that need. The low number of asthmatics recruited from the A&E Department was partially due to the fact that usually the children attending the asthma bay were in status asthmaticus, and all efforts were concentrated on resolving the immediate crisis--an asthmatic attack--rather than discussing the study.

Table 2-8. Spatial Distribution of the Total Asthma Study Population (N=335).

Region	Asthmatics Frequency	Asthmatics Percent	Controls Frequency	Controls Percent
General:				
Urban	93	55.4	86	51.5
Rural	75	44.6	81	48.5
Parish:				
Christ Church	14	8.3	4	2.4
St. Philip	13	7.7	9	5.4
St. John	20	11.9	25	15.0
St. George	6	3.6	5	3.0
St. Joseph	3	1.8	0	0
St. Andrew	3	1.8	5	3.0
St. Lucy	6	3.6	5	3.0
St. Peter	20	11.9	19	11.4
St. James	16	9.5	17	10.2
St. Michael	58	34.5	69	41.3
St. Thomas	9	5.4	1	0.6
Demographic region:				
Densely populated (within 2 miles of Bridgetown)	39	23.2	52	31.1
Semi-urban	40	23.8	25	15.0
Peri-urban (in the urban district, visible agriculture)	12	7.1	5	3.0
Suburban height/ terrace	5	3.0	0	0
Rural tenantry	69	41.1	85	50.9
Mixed rural (height/ terrace, government housing, tenantry)	3	1.8	0	0
Total:	168	100	167	100

Personal and Socioeconomic Characteristics

The mean age was 9.7 years for the asthmatic population and 9.9 years for the controls. There were 78 girls (46.4%) and 90 boys (53.6%) in the asthma group and 87 girls (52.1%) and 80 boys (47.9%) in the control group.

Of the 177 informants, 165 (93.2%) were female and 12 (6.8%) were male. The mean age of informants was 35.6 years (median=34, mode=28). The range was 17 years to 81 years. In two cases the informant was also the patient; these informants were a 17-year-old female and an 18-year-old male and were deemed capable of providing reliable household and health-related information because they both were reportedly responsible for the other members in the household (mother and grandmother, respectively). All informants were black except for one male who was caucasian and one female who was East Indian. All children in the study were phenotypically black.

Marriage and family patterns have been well-described in the Caribbean in general (Clarke 1957; Solien 1960; Smith 1962; Rubenstein 1977) and in Barbados specifically (Byrne 1966; Nag 1971; Ebanks et al. 1974; Dann 1984, 1987). As in other Caribbean cultures, conjugal relationships in Barbados are not dichotomous in nature; even the census bureau recognizes this characteristic by delineating "union status" as either married, common law, visiting, separated/divorced from married partners, separated/divorced from common law

partners, and never married or never in a common law relationship (1980/1981 Population Census 1985). Legal marriage typically occurs later in life; for example, from the 1980 census, 41% of women between 14 and 44 years were married and 59% of women over 44 years were married (1980/1981 Population Census 1985). Currently in Barbados the number of children born to unwed parents is approximately 75%, but more importantly from a socialization standpoint is the fact that over 38% of households are headed by a single female (Dann 1984).

In the asthma study, 61 (34.5%) of the informants reported that they were single and 88 (49.7%) were married or in a common-law union. Table 2-9 illustrates the breakdown of unions by informants.

Table 2-9. Frequency and Percent of Types of Unions per Informant (N=177).

Type of Union	Frequency	Percent
Single	61	34.5
Visiting	19	10.7
Common-law	51	28.8
Married	37	20.9
Widowed	3	1.7
Separated/divorced	5	2.8
Separated/divorced, and living with another person	1	0.6
Total	177	100

Dann found that marital status was positively correlated to both income and age (1987). Similarly, in the asthma study,

marriage was positively correlated to the "amenities" score ($f=4.73$; $df=6, 170$; $p<0.001$) and to age ($f=6.92$; $df=6, 170$; $p<0.001$).

As previously discussed, little credence was given in this study to the relationship between socioeconomic status and classification of occupation type[9], although it is worthy of mention that occupation of the informant and the "amenities" score were strongly correlated ($f=15.03$; $df=7, 169$; $p<0.001$). Not surprisingly, occupational status of the informant was also positively correlated to gender ($f=7.65$; $df=1, 175$; $p=0.006$) (with the relatively few male informants being employed in the higher-ranking jobs), to education level at the 0.10 level ($f=2.78$; $df=2, 174$; $p=0.06$), and to the percent of all employable adults in the household who were currently employed ($f=14.02$; $df=7, 169$; $p<0.001$). Only 29.4% stated that all adults living in the home were employed, and 16.4% of the informants stated that less than half of the adult household population was currently unemployed. In eight of the homes no employable adults were formally employed at the time of the study.

Analysis and Presentation

Data from the entomological surveys in Phase I and interviews and biomedical tests in Phase II were coded and entered into a database program (Symantec Corp. 1991). A data set was created from the database and frequency distributions, bivariate (Pearson's R, Chi-square, t-tests,

and ANOVA) analyses, and regression analyses were produced for further interpretations, using logistic analysis procedures for personal computers (SAS Inst. 1988).

Summary

In summary, this chapter has illustrated the make-up of the sample population chosen to test the hypothesis that modernization of the domestic environment provides a better habitat for certain household pests, which in turn are etiological factors in the disease asthma. The design of the 2 phases in which data were collected was outlined, and the focal independent and dependent variable(s) were described. A review of the infrastructure of contemporary Barbados illustrates an overall "representativeness" of the sample population. The next step in the process of proving or disproving the null hypothesis is a review of the evolution of the setting for this study--the Barbadian home.

Notes

1. R.P. Naidu, M.D., Director of the Accident and Emergency Department, Queen Elizabeth Hospital, Martindales Road, St. Michael, Barbados. Personal communication.

2. E. Ferdinand, M.D., Acting Chief Medical Officer in 1991, Ministry of Health, Jemmott Lane, St. Michael, Barbados. Personal communication.

3. L. Prescod, Director of the Barbados Drug Service, Ministry of Health, Jemmott Lane, St. Michael, Barbados. Personal communication.

4. The international value of the Barbados dollar (BDS) is fixed to the U.S. dollar at a rate of BDS 1:US 2.

5. M. Carter, President, Asthma Association of Barbados, St. Michael, Barbados.

6. Services at QEH include inpatient, outpatient, and casualty, plus eight polyclinics and five outstations, centrally-located in each parish and easily accessible via primary and secondary roads. In addition to the public sector, Barbadians have the option of utilizing the private health care sector. The 539-bed public hospital began servicing the population in 1964. In 1990, 18,767 inpatient admissions were accommodated and 6,590 inpatient surgeries were performed (Sergeant, personal communication).

7. M. Sergeant, Project Implementation Design Unit, Ministry of Health, Jemmott Lane, St. Michael, Barbados. Personal communication.

8. Residential sub-divisions are referred to as "terraces" and/or "heights" in Barbados. Usually they are built on larger lots than are the lower socioeconomic homes in the urban sector and village tenantries, ranging from 4,000 to 8,000 square feet. Terraces and heights are representative of Barbadian suburbia, and are discussed in detail in Chapter 3.

7. Due to the 1991 crisis, informants were requested to report, to the best of their knowledge, household financial information that applied to the period of time <u>prior</u> to the national debt crisis of October, 1991.

8. "High purchase" is a method of acquiring household items by credit. Items purchased via high purchase range from kitchen appliances, furniture, carpeting, fans, even bicycles. Particularly expensive items, such as large appliances (e.g., washing machine, stove) typically require a one-third cash payment at the time of purchase, followed by monthly payments. In 1991, Courts, one of the largest appliance stores on the island, based high purchase payments on the cash price of the item plus 37.7% interest. On all purchases the payment schedule varies, but it is usually on a monthly basis for up to two years.

9. "Occupation" was categorized using the following scale: (1) unemployed (2) student/housewife; (3) retired; (4) unskilled labor; (5) skilled and semi-skilled manual; (6) skilled and semi-skilled non-manual; (7) white collar; (8) semi-professional; and (9) professional/managerial. This format was adapted from the Census categorization and the study by Dann (1984).

CHAPTER 3
SETTING THE STAGE FOR A CASE STUDY: BARBADOS LAND TENURE PRACTICES AND EVOLUTION OF THE BAJAN HOUSE FORM

A Historical Review of Land Distribution

Perhaps what makes the development of the domestic environment in Barbados particularly unique is the role that Barbadian social history has played--and continues to play--in its evolution. It is specifically this historical factor which the author believes to be most significant in understanding the trend in Barbadian housing. In the following paragraphs I will demonstrate this significance by first reviewing the peopling process and subsequent stratification of classes in early Barbados and the pivotal role that the economy, particularly the sugar industry, has played in these processes. Land distribution in Barbados will be addressed, to serve as a thorough preface for Chapter Four, an analysis of the traditional house forms. This review, in addition to findings for the sample population (presented in Chapter Four), will identify specifically what elements in the Barbadian house form are being "modernized," which, in the process, will allow the author to qualify the term "modernization."

The Birth of Barbadian Society: The Pre-Emancipation Period

The first permanent settlement in Barbados was established in 1627, by a group of English merchants. In the immediate years to follow, a political squabble ensued between the Earl of Carlisle, who obtained legal proprietorship from the King of England and the original merchants. By the mid-1640s Barbados was an established, profitable English colony, engaged in a monoagricultural industry just as its sister colonies. Focusing on the successful Virginia colony to the north, the original Barbadian merchants began producing tobacco, an industry that was short-lived due to the glutted London market in 1631 and the notoriously poor quality of Barbadian-produced tobacco. In the early 1630s the planters shifted to cotton, followed by indigo in the 1640s; both of those markets collapsed from oversupply, just as tobacco had in the early years.

In 1640 sugarcane monoculture was introduced by Dutch entrepreneurs driven out of Brazil. Sugar would dominate the economy until the 1950s when attempts were made to diversify agriculture and expand the manufacturing, tourism, fishing, and government sectors, and to a lesser degree, the production of crude oil. The establishment of the sugar industry in Barbados marked a turning point in Barbados both economically and socially. By the 1660s, Barbados was perceived as the "most precious jewel of the British Crown"

(Williams 1970, p.114). A 500-acre plantation that sold for 400 pounds in 1640 soared to a value of 7,000 pounds by 1648 (Williams 1970). By the late 1600s, sugar exportation from Barbados was reportedly worth 6,195,200 pounds, more than the total exports of the American colonies (Roach 1984). In Beckles' words, Barbados had transformed from a "struggling frontier community to a wealthy sugar economy" in less than half a century (1990, p.23). By the mid-1650s a planter aristocracy had been established in Barbados, thanks to the successful sugar industry.

Land Allocation and Stratification of the Planter Class

Until the rise of the sugar industry, Barbados was a small farm economy. The earliest records of land allocations between 1629 and 1638 reveal a total of 707 grants, totaling 67,929 acres, at an average size of 96 acres (Campbell 1984). These figures, however, do not include grants to the original settlers, most of which were 100 acres or more. In 1645, the less than 100,000 arable acres in Barbados were divided among 18,300 white men, and of those, 11,200 were proprietors, most of whom held less than ten acres of land (Williams 1970). The reference of "ten acres" bears significance. In the first land grand of 1630, the governor at that time, under the direction of the Earl of Carlisle, distributed parcels of 100 acres per "ten men", which reflected a law stating that a landowner was required to employ "one man for every ten acres which he

possessed" (Campbell 1984, p.119). The law was designed to insure that all indentured servants would receive their due parcel, ten acres, at the termination of their servitude, thereby assuring the colony a large white population. The law actually set a precedent in which only men owning ten acres or more were considered "freeholders" and could vote, as opposed to those owning less than ten acres, or "freemen," who could not vote. The important point, however, is that within five years after the introduction of sugar monoculture, and less than two decades after the original settlers, all of the arable land on Barbados was parcelled. Single-minded business ventures focusing on monoculture industry--first tobacco and eventually sugar--necessitated the swift and thorough removal of rain forest vegetation. By 1670, the relatively flat island was virtually transformed into a 166 square mile cane field, as all arable land was under sugar cultivation (Beckles 1990).

An important determining factor as to who would become a <u>successful</u> sugar planter with the introduction of cane to Barbados was the size of the land holding a proprietor owned prior to the introduction of cane agriculture. Sugar cane required three times the labor force and livestock needed for other plantation crops. In comparing average sugar plantations versus nonsugar plantations in Jamaica in 1774, Williams concludes that the sugar plantations had two and a half times more acres, more than five times the labor force,

and twice as much livestock as the nonsugar-producing plantations (1970). Furthermore, because of the investment necessary in labor, livestock, and equipment for sugar processing, more acres were required for the return in capital. The tobacco farmer who owned only 20 or 30 acres of land had to purchase his neighbor's property and increase his landholding if he wanted to become a competitive plantocrat, or sell off his small parcel to a wealthier landowner and leave the sugar business altogether (Watson 1970). It has been calculated that a profitable sugar plantation required up to several hundred acres, depending on the topographical location of the land, and as much as one laborer for each acre of cane, or at least a ratio of 1:2 (Dunn 1972). An interesting feature in the Barbados case was the subdivision of particularly large properties into smaller, more manageable estates of 300-500 acres (Beckles 1990). This is in contrast to other sugar-producing colonies in the West Indies; for example, the average size of a sugar plantation in Jamaica was 441 acres and a number of Jamaican plantations were larger than 2,000 acres (Williams 1970).

Substantial land consolidation did occur between 1650 and 1665, but Beckles (1990) warns that the degree of consolidation has been exaggerated in the literature. For example, Williams (1970) noted that by 1667 there were only 745 plantation owners, with holdings ranging in acreage from

200 to 1,000 and an average size of 300 acres. While the acreage estimates are accurate in this summary for the most prominent planters, the total number of land owners is seriously underestimated. Census data from 1680 demonstrates that there were in fact 2,639 property holders and the majority of those were small farmers, with a mean farm size of 29 acres (Dunn 1972). That same census included a classification of Barbadian property holders, divided into 175 big planters (those with 60 or more slaves), 190 middling planters (those with 20-59 slaves), and small 1,041 planters (those with 10 or more acres, and zero-19 slaves) (Dunn 1972). The number of "freeholders" totaled 1,125 and freemen totaled 1,186 (Dunn 1972).

Dunn (1972) refers again to the 1680 census in his discussion of the emerging planter elite. Although those 175 "big planters" represented only 7% of the total property holders, they owned 54% of all property. This factor alone was not unique to colonial West Indian plantocracy; in fact, it was quite typical. But what made the Barbadian plantocracy unique was the fact that many of the big sugar magnates of the eighteenth century could trace their ancestry to the earliest settlers of the 1630s and 1640s, and this, they believed, gave them the inherent ability to politically and economically control Barbados (Watson 1979). In fact, only 20% of the 175 biggest planters from the 1680 census arrived in Barbados <u>after</u> the development of the

sugar economy in the 1650s. Watson (1979) explains that, by reviewing land ownership, military rank, and public offices held, approximately 120 families can be identified as the most dominant and influential in Barbadian history, and many of these families are still considered the "high whites" of Barbados today. From 1675 to 1685, 109 of the 175 big planters held at least one office, the more important offices being limited to men owning larger portions of land (Dunn 1972).

Another historical difference between Barbados and its counterpart colonies is that it never experienced the same degree of absenteeism as did, for example, Jamaica, although the financial ability to act as an absentee planter was an aspiration of most planters and was practiced on a small scale. Absenteeism was initially deterred in Barbados by seventeenth century laws that restricted re-election to prestigious offices to men currently residing on the island (Dunn 1972). A significant constraint for most planters was the relatively small size of their land holding, a factor that limited absenteeism since profits were insufficient to maintain a life of luxury back in England. Beckles (1990) attributes low rates of absenteeism to the "patriotic consciousness" of the planter elite that climaxed during the American Revolution, as Barbadian demands for greater political autonomy ensued. Indeed, absenteeism remained quite low between 1700-1825; Watson (1979) notes that, from

a list of 54 prominent planters over the 125-year period, only 3 were absentee-owned for that span of time.

Another factor contributing to the low rate of absenteeism--and indirectly to the creation of a stable white upper class--was a sort of "permanent" mentality among the planter elite, a notorious attribute of which they received much comment and even ridicule. To Barbadians, the fact that they were Barbadian-born and could trace their ancestry to the earliest settlers evoked a greater sense of pride than did their English ancestry. As Karl Watson notes, this emotion was and still is viewed by the outsider as a "...somewhat ludicrous...emotion which borders on xenophobia for what is, after all, a rock in the ocean..." (1979, p.34). Nevertheless, it can be argued that the permanent white plantocrats contributed significantly to the stability of Barbadian society in their effort to recreate the elite country lifestyle of England and in their perseverance to succeed for generations in the production of a crop that was both suitable and profitable for the island.

A series of boom periods and disastrous episodes served to forge a cohesive class of planter elite and further solidified their allegiance to Barbados. By the end of the seventeenth century profits from sugar lowered, secondary to competition from other West Indian countries who had successfully penetrated the large-scale sugar economy (Beckles 1990). Declining yields and soil erosion

contributed to losses in profit and served to further marginalize the small planter (Beckles 1990). Beckles (1990) explains that, while Barbados contributed nearly 42% of the total sugar exports to England in the years 1700 to 1704, their share dropped to less than 6% by 1779. War throughout the eighteenth century resulted in losses at sea and a shortage of investment funds for the colonies, and natural disasters such as the yellow fever epidemic of 1703, the hurricane of 1731 and again in 1780, and the drought of 1733-1734 took a toll on human life as well as the infrastructure in general (Hoyos 1978; Beckles 1990). But these disasters were interspersed with brief moments of prosperity, including the damage to sugar industries in Guadeloupe and Martinique during the Seven Years War, a sudden rise in prices between 1789 and 1794, the slave revolution in St. Domingue, and relaxed trading with the United States by the end of the century (Beckles 1990).

A substantial white middle class had emerged by the mid-eighteenth century, constituting some 25% of the total white population (Watson 1979). This group was subdivided into an upper and lower middle class and stratification was based on land ownership. Many of these planters were engaged in the cultivation of cotton and a number of the larger of these middle class planters were propelled into the elite class in the following century. The "lower" middle class yeomanry concentrated on cotton, livestock,

ginger, vegetables and ground provisions (Watson 1979). Despite the seemingly high number of small landholders operating in the 1680s, a large number of white laborers and small planters emigrated from Barbados in the 1660s and 1670s (Chandler 1986; Alleyne & Fraser 1988). By 1682 the large-scale movement had carried nearly 30,000 people away from Barbados; whereas the white population had equalled the slave population in the 1650s, the ratio in the 1680s was just under 20,000 whites to 60,000 black slaves (Chandler 1986).

Indentured Servitude and a White Lower Class

Initially, Barbados was peopled by merchant entrepreneurs and indentured white servants. During the 1630s and 1640s, indentured servants comprised more than half of the white population (Beckles 1990). In general, the white servants were Scotch, Irish, and English. They included the following: voluntary servants who, for various reasons, migrated under the Indenture System and contracted their services for a period of five to seven years; convicts, sold into hard labor, or "Barbadoed," for a usual period of 10 years, in lieu of the death penalty; and political prisoners or prisoners of war.[1]

Even after the introduction of sugar and the concurrent demand for large-scale labor, Barbadian planters preferred white indentured servants over African slaves,[2] at least initially. Beckles (1981) contends that the reasoning

behind this preference had to do with the literacy and technological skills necessary for the sophisticated process of sugar manufacturing, skills with which they were probably already familiar due to the agro-industrial revolution in England. In fact, in the 1660s, the English mercantilists were complaining about the "technology drain" resulting from the servant trade to the West Indies (Beckles 1981).

Increasingly was the problem of what to do with servants at the end of their term, due to limited subsistence options secondary to land scarcity and the prohibition of colonial manufacturing, as decreed by the Crown. Despite the policy of the 1630s, the emerging class-conscious plantocracy prevented land distribution to freed servants by misinforming the governor of the number of servants that they actually owned, thereby allowing the planters to continually enlarge their own estates, which ultimately increased their political and economic hegemony (Beckles 1980). The planters succeeded in this deception by giving the 10 acre plots to their children, who would appear in the census as freemen. Consequently, freed servants became overseers, wage workers, and artisans, but did not, on the whole, engage in subsistence farming; only the highly skilled artisans eventually accumulated enough capital to become landowners. Their servitude was often prolonged following the passing of the 1661 Servants Act, an act to extend the length of servitude and designed to maintain an

adequate labor force by penalizing servants for every minor offense (Watson 1970; Beckles 1981).

The gradual replacement of white servants with African slaves,[3] coupled with the scarcity of land, contributed to a new social strata--a white wage proletariat. These peasants were restricted to the rab lands of the east and north coast parishes, regions that were topographically undesirable for the production of sugar and marginal in their capacity for subsistence farming (Watson 1970, 1979; Roach 1984). The rab lands where most of the poor whites settled were the hilly regions, and the parish of St. Andrew was increasingly referred to as the "Scotland District." While it has been inferred that these freedmen settled in the Scotland District because of its physical resemblance to their homeland (Roach 1984), a more plausible explanation is the fact that the marginal soil of the eastern parishes was the only land that they could secure, as the plantocrats had little use for it. The poor whites were often described as living in conditions at least as bad, if not worse, than the black slaves, and they were despised equally by white and black Barbadians.[4] In fact, they typically incurred a lower standard of living in the transformation to freedmen because their wages were less than those of indentured servants.[5] According to Roach, "...[t]he provision allowed to the indentured Red Leg was five pounds of salt fish or salt meat per week and a few yams or sweet potatoes. After

working for 5 or 7 years some of these servants received the princely sum of 1-15.0 pounds" (1984, pp.138-9). Subsequently, indentured servants became the lower class whites of Barbados, an anomaly in West Indian social history.[6]

African Slaves: An Alternative Labor Source

A nominal number of African slaves were introduced to Barbados with the first English settlers. Prior to the introduction of sugar, Barbados had a ratio of one African slave to three white men (Williams 1970). By 1700 that ratio was reversed--there were 15,400 whites and 50,100 blacks (Beckles 1990). The point in time in which the African population apparently reached significant numbers[7] is evident in the passing of the "Act for the better ordering and governing of Negroes" in 1661 (Dunn 1972). The 1661 Code was revised in 1688, and the new Code legally suppressed cultural behavior such as the use of drums and other instruments and re-classified slaves as real estate rather than chattel, thus eliminating their right to own property (Dunn 1972).

By the end of the seventeenth century a significant free black population existed in Barbados. Freedom was most often granted from masters by will and deed; between 1650 and 1725, 201 slaves were manumitted by means of their masters' wills (Hoyos 1978; Beckles 1990). Free blacks usually established themselves as tradesmen, tavern

attendants, and petty hucksters in the urban sector, and a few gained prominence within the business community (Handler 1974; Hoyos 1978; Beckles 1990). Generally, agricultural work was shunned because of the subservient status that it implied (Handler 1974). Furthermore, it was difficult for freedmen to acquire substantial portions of land, although there were no legal restrictions against doing so; Handler notes that when freedmen did acquire land, the spots were generally quite small--73.3% were less than three-quarters of an acre--and they were usually house spots in the metropolitan region (1974).

It was not uncommon for white planters to bequeath small plots of land to their manumitted slaves, typically between one to ten acres, and usually--but not always--accompanied with instructions to return the land, upon the death of the manumittee, to the testator's white heirs (Hughes 1981). A unique case resulted in the creation of a entire black freehold village, which came to be known as "Sweet Bottom Village," situated in one of the prime sugar-producing parishes, St. George. Upon the death of Francis Butcher in 1777, a 20-acre parcel of land was bequeathed to seven slaves, four of whom were the mulatto children of Butcher, and instructions for their manumission were included. Instructions included the following:

> Having freed 7 slaves and provided for the freeing of 2 more by Hollingshed, Francis Butcher went on to provide for their material support. He ordered his executors to buy 20 acres of land near Golden Ridge...The land was to be divided into 5 equal parcels of 4 acres each. Shingled stone houses 12 feet by 25 feet and partitioned into 2 rooms were to be built on each 4-acre lot. The owners of each lot were to be given livestock and the right of access to a supply of water from Golden Ridge... (Hughes 1981, p.270).

This Act was unprecedented, but was repeated in 1832 by a Christ Church planter who bequeathed 36 acres to his seven colored children and again in 1833, when the owner of Warner's Plantation, also in Christ Church, left 29 and a half acres to 16 colored persons (Hughes 1981). Similar cases followed in the mid- and late-nineteenth century, contributing in small part to a growing landed peasant society (Dann 1984).

Acculturation of the Classes

Despite class consciousness, the increasing ratio of black African slaves to a small, permanent white population resulted in the inevitable process of acculturation. During the initial stages of the sugar boom, indentured servants worked in field gangs with African slaves on the larger estates and played a part in teaching the slaves the technical aspects of cane cultivation (Watson 1970; Beckles 1981). Young white creoles were exposed to African mores and values from the time of birth, and by 1750 the fourth and fifth generation Barbadians were commented upon by such visitors as George Washington, who noted that "the Ladys

generally are very agreeable but by ill custom...affect the Negro style" (Watson 1979, p.42).

Watson observes that it was the lower class whites who facilitated the acculturation process in Barbados, by serving "...as a buffer group against the enslaved population" and the upper class whites, thus functioning "...as a filter for African culture on the island and, as such, were an extremely important agent in the creolization process" (1979, p.59). On the other end of the spectrum, "...as the white group closest to the slaves, they were crucial to the diffusion of European culture" (1979, p.59).

The relatively small number of African-born slaves at an early point in Barbadian history resulted in a weakening of African traits and practices. Beckles (1990) laments that these ethnic divisions were lost by the eighteenth century, and by 1817, only seven percent of Barbadian slaves were African-born, resulting in a colony with the largest creolized slave population in the West Indies.[8] Conversely, the 1817 slave census of Jamaica reported that the African-born slave population was 36% of the total slave population (Watson 1979), more than five times the proportion for Barbados. A high degree of creolization is perhaps most evident in the area of linguistics; compared to the other West Indian islands, Barbados has the least-developed Creole language and the lowest percentage of African survivals. Creolization was accelerated no doubt by a system that

rewarded those with the least-African traits, thus fostering contempt among slaves for that which was in fact their own[9] (Watson 1979; Beckles 1990).

By the end of the period of slavery, Barbadian society was well-formed and highly stratified. Social stratification had significant bearings on land distribution that would continue to restrict class mobility and which would ultimately set the precedent for standards of living and housing practices among the various classes. In pre-emancipation society, the white planter elite controlled the largest land holdings, while the middle class white yeomanry held the smaller holdings. In contrast to other West Indian islands, a significant poor white proletariat emerged, who was landless, similarly the black slaves, and was unable to hold property. Increasingly a freed black and colored population developed, some of whom were landowners. With emancipation, there was some modification of this class structure, but very few changes in regard to land distribution and subsequently standard of living.

Emancipation and the Landless Proletariat

In 1834, the imperial campaign for an end to slavery materialized into the Emancipation Act, and as of August 1 of that year, all slaves under the age of six years were declared completely emancipated, while those over six years would be freed after a four year apprenticeship. The total number of freed slaves in 1834 was 83,150, and Beckles

(1990) calculates that this resulted in a total of 501 apprentices per square mile, making Barbados the most densely populated island in the Commonwealth.

In response to the Assembly's Act of 1838 for the abolition of the Apprenticeship System, the Barbados legislature instituted the Masters and Servant Act, later known as the Contract Law, designed to maintain political and economic control over the freed blacks. The Contract Law stated that any worker who provided continuous labor for five days or more was thus hired for one year, and one month's notice was required by either party for a legal dissolution (Beckles 1990). The worker was entitled to live on the plantation and reside in a cottage provided by the planter, but once the contract was dissolved, he was to leave the property and was only entitled to the value of crops that he planted, a value to be determined by the parish Justice of the Peace (Beckles 1990). Furthermore, the worker could be evicted from his job and cottage without wage compensation if his behavior was deemed "insubordinate" by the planter and he could be imprisoned for crimes as petty as foul language (Beckles 1990; Fraser et al. 1990).

In an attempt to modify the Contract Law in favor of the laborers, the Governor ordered a modification in 1840 that lessened the contract from one year to one month, forced the planter to reduce rent on cottages, and required workers to pay rent rather than use labor in exchange for

cottage occupancy. But these modifications only served to strengthen the planter's position by transforming the free wage worker into what Beckles (1990) terms a "located plantation tenant," since laborers were forced to work exclusively for the estate on which the lived.

In short, very little had changed for the black laborer in the transition from slavery to emancipation. The planter class continued to dominate most of the arable land in Barbados and the price of land was prohibitively high for the wage proletariat. While planters did allocate marginal, rab land to workers in return for their labor, residency usually was dependent on the worker's allegiance to a planter and the land was not perceived as his own. There were, increasingly over time, instances of ex-slaves becoming leasehold users of land on estates for which they did not work, although the number of these cases were proportionately small (Beckles 1990). The very small population of black freeholders were usually from the artisan sector, persons who had accumulated savings enough to purchase small pieces of land. This group was small, however, totaling only 4,982 by 1878 (Beckles 1990). Thus, the tenantry system limited the emergence of a peasant class; the planter class succeeded in legally establishing a landless proletariat and maintaining their absolute control over a stable labor force.

One response to the restrictive Contract Law was mass emigration of laborers to destinations such as Trinidad and Guyana. Of even greater importance was the period between 1859 and 1914, during construction of the Panama Canal, when as many as 20,000 Barbadian men emigrated (Schofield 1991). This period was one in which remittances from Canal workers made up the largest proportion of foreign currency, and a number of families seized the opportunity to purchase their own land (Schofield 1991). Between 1904 and 1921, at least 70,000 Barbadians emigrated to the Canal, North and South America, depleting the population by 2.3% each year (Lowenthal 1957). Thus began the pattern of short-term emigration and remittance in Barbados, a practice that would play a role in family economy well into the twentieth century.

A restructuring of land ownership by the upper class whites occurred during the economic depression of the 1880s and 1890s, in which the plantocrats were joined, and in many cases marginalized, by the newly-formed merchant elite. Intermarriage and dependence on merchant financing for an indebted sugar economy resulted in the increasing takeover by urban merchants of the rural sugar estates and the subsequent diversification of the merchants' economic basis (Watson 1979). These changes probably served to solidify the minority white upper class and better prepare them for the tumultuous decades of the mid-twentieth century, in

which Crown reforms and eventual Independence would pave the way for acquisition of political control by the once oppressed black Barbadians.

Steps Towards Reform

The post-emancipation period resulted in a majority landless proletariat population, who did, ironically, tend to own their own homes (to be discussed). Lowenthal (1957) noted the curious scenario in which the highest proportion of land owners lived in the most remote parishes of St. Lucy and St. Andrew, the "poor soil" parish of St. James, and the arid parishes of Christ Church and St. Philip; paradoxical when one considers the importance of land ownership to a West Indian and that such prestige should belong to those in some of the poorest areas of the island. The suggestion that land in St. James, Christ Church, and even St. Philip was considered "poor" is another paradox in view of the extreme importance they would bear in the blossoming tourist and manufacturing industry in the twentieth century.

Some of the most dramatic changes in land distribution and housing occurred during the Tom Adams administration between 1976 and 1985. In 1980, the Tenantries Freehold Purchase Act gave all tenants occupying land on tenantries the opportunity to buy their house spot. A qualified tenant was one who, at the time of the Act and thereafter, had been residing on the lot for five consecutive years, or for five years out of seven, and who had used that spot for his/her

own habitation or for the habitation of his/her spouse, child, sibling, or parent (Tenantries Freehold Purchase Act 1980). Moreover, allowances were made for tenants who, for the purpose of work outside of Barbados, had undergone occasional absences. In the 1980 Act, 193 plantation tenantries were included in the legislation (Tenantries Freehold Purchase Act 1980). For plantation tenantries, the price was set at $1 per square meter, with a minimum purchase price of $300, and for nonplantation tenantries, the price was based on what could be expected if the land was on the open market (Potter 1986). In some cases, tenants could purchase their spot for as little as ten cents per square foot (Hudson,[10] personal communication). An amendment was submitted in 1989, allowing for the purchase of land on nonplantation tenantries of five lots or less (Tenantries Freehold Purchase (Amendment) Act 1989). Similarly, the Tenantries Development Act of 1980 was designed to assist in the overall objective of the Tenantries Freehold Purchase Act--to improve national housing standards, as promised by the Adams administration--by gradually improving those tenantries that required upgrading or even installation of electricity, piped water, and roads (Potter 1986).

During the 1960s and 1970s, economic growth and the desire to improve personal housing standards were represented by an increase in commercial bank loans for

housing and land; the percentage of loans issued for this purpose increased from 7.9 in 1969 to 22.8 in 1977[11] (Nurse 1983).

In summary, a historical review of land distribution in Barbados illustrates limited access of land for ownership to the majority working class, a phenomenon that emerged with sugar monoculture. The fact that land was limited to the social elite set a precedent; throughout the remainder of Barbardian history, owning land was synonymous with social status. This factor would play a significant role in the evolution of the house form and contemporary aspirations for housing, or, "modernization." At this point, a review of contemporary land distribution patterns will be presented.

The Contemporary Spatial Distribution of Land and People

The Impact of Twentieth Century Reforms

Barbados is and throughout most of its history has been one of the most densely populated countries in the world. As Lowenthal simplistically stated, "[t]he island is crowded today partly because it always has been crowded" (1957, p.449). According to the 1990 census, the total population is 257,083, which yields a density of 1,549 persons per square mile (unpublished data). The rate of growth has actually declined in recent years; the average annual increase was 0.4% between 1970 and 1980 (Town & Country Development Planning Office 1988) and that figure is

expected to remain unchanged by the year 2000 (United Nations 1991). The reasons for this stabilization in growth are primarily a declining fertility rate and continuing out-migration (Roberts 1955; Nag 1971; Ebanks et al. 1979). But, what has changed dramatically within the last four decades is the distribution of the population rather than the density, and this is dependent on a host of factors, including sociohistorical, topographical, and economical.

A comprehensive social history heretofore has been presented so as to illustrate stratification of the Barbadian population prior to the mid-twentieth century and the economic basis for that stratification--sugar. The nature of the labor system required for large-scale sugar production demanded a work force too large to guarantee adequate land and housing following the collapse of the systems on which it was based--indentured servitude, slavery, and post-Emancipation tenantries--and resulted in a majority population of landless proletariats; this in turn led to a social revolution in housing reform. The decline of a monoagriculture industry and the emergence of urban-based economies, in addition to the inevitable integrative process into the "new world order," brought about by expanded trade following Independence, international communications, and acculturation secondary to large-scale emigration, have all served to redirect the focus on the urban sector rather than the rural sector.

These revolutionary changes have had a major impact on the ideology of the "preferred place of residency" in Barbados. In addition, a relatively new feature in ideology of residency has emerged, and that is the importance of topography. Prior to the decline of sugar, topography played only a marginal role in choice of housing, since most of the arable land was cultivated for cane and because tenants, forced by the planter to reside on designated rab lands, had little choice as to where they could live. With a decline in the sugar economy, Barbadians are probably choosing house spots based on the topographical merits and not simply availability of land.

Barbadian Economy and Its Role in the Urban/Rural Sector

Population demographics in Barbados cannot be understood without first discussing the economic transition that has occurred within the twentieth century. The pattern is similar to that found throughout the developing world--a rapid decline in the rural, agricultural sector, and uncontrolled and poorly planned urban growth. Yet the effects on a very small island, whose population density exceeded that of most other countries prior to the economic transition, deserve special mention, particularly in the context of defining "what is urban" and "what is rural."

The most significant variable in the Barbadian economic transition is the decline of sugar as an industry. It is a controversial topic, and continues to foster racial

divisiveness between what is left of the estate white planters and black politicians. The spark was ignited when Prime Minister Barrow made his "cane blade speech", on May Day, 1967, which was designed to promote the diversification of the island economy and encourage women to venture out into nontraditional modes of production, such as manufacturing. The prime minister stated that he lived for the day when he no longer could see one blade of cane on Barbados. J.C. Hudson of Carib Agro-Industries notes that the comment was taken out of context and capitalized upon by extremists wanting to end agriculture altogether because of the stigma of subservience and slavery; Hudson contends that Barrow was in fact an avid supporter of the mechanization of agriculture and the continuation of sugar as a major contributor in the economy (personal communication).

In 1963, the sugar industry accounted for 24% of the gross domestic product (GDP), but it fell drastically by 1972 to 8% and to 6.6% in 1976, putting sugar behind tourism in GDP (10.3%) (Nurse 1983). The year of greatest output ever recorded was in 1967, but output declined by 50% in 1975 (Nurse 1983). Declining output was compounded by a steady decline in yields of cane per acre, which was probably a result of several factors, including poorer varieties of cane, compaction of soil secondary to mechanization equipment, cane fires, falling acreages as a result of urban development and land use changes and,

perhaps most importantly, a decline in rainfall for that period (Nurse 1983). The small size of agricultural holdings and subsequently the small yield in agriculturally-based profits for the small farmer are no doubt another factor in the declining sector.

Internal complications with the sugar industry were compounded by external factors, most notably the eroding world market, in which prices peaked in 1967, but dropped below production cost in 1970 (Nurse 1983). The cane harvest of 1992 has been the worst in 100 years, at 54,000 tons, yielding only $50 million and necessitating the unprecedented importation of sugar to Barbados in order to meet sales demands (Hudson, personal communication). Currently there are approximately 100 working plantations, and of those, 60% are bankrupt (Hudson, personal communication).

Another factor contributing to the decline of the sugar industry--and a curious one--is the increasing labor shortage. This situation has actually spawned the need to import labor into the island. Migrant crop workers have traditionally come from neighboring St. Vincent and St. Lucia, but in recent years, most have come from Guyana (Schofield 1991; Hudson, personal communication). In 1990, 106 of the 108 foreigners granted work permits for cane cutting were Guyanese (Schofield 1991). This importation of

labor is in spite of the fact that the unemployment level continues to rise.[12]

The first documented labor shortage appears to have occurred in the 1960s, due to large-scale emigration and increasing disenchantment among young Barbadians to work on plantations[13] (Schofield 1991). A new factor in the shortage--and evidence of disenchantment among the youth--is the increasing average age of cane workers (57 years in 1990) (Schofield 1991). An elderly couple in Bridgetown, discussing the "unfortunate" decline of agriculture, lamented that young Barbadians are "embarrassed" to see a parent working in the fields and will deny their parent's occupation when asked. Another elderly woman attributed a "get rich quick attitude" among the Bajan[14] youth as responsible for the decline in the agricultural labor force. "Young men want ta wear a coat an' tie now... de too good for cuttin' cane".

Tourism[15] and manufacturing experienced substantial growth in the 1960s and into the 1970s, followed by a period of negative real growth in 1974 and 1975, and a rebound again into the 1980s (Town & Country Development Planning Office 1988). Of recent years, general services, government services, and retail and wholesale trades business have been major contributors to the economy. Table 3-1 illustrates shifts in the GDP between 1970 and 1980.

Table 3-1. Percentage of gross domestic product (GDP) by sector.

Sector	1970 (%)	1980 (%)
Sugar	9.3	6.3
Other Agriculture & Fishing	4.6	3.3
Mining & Quarrying	0.6	0.9
Manufacturing	8.7	12.7
Electricity, Gas & Water	1.7	1.5
Construction	9.1	7.0
Wholesale & Retail Trades	29.4	21.4
Tourism	9.3	11.7
Transport, Storage & Communication	5.6	5.8
Business & General Services	7.0	14.8
Government Services	14.7	14.6
Gross Domestic Product Factor Cost	100.0	100.0

Source: Town & Country Development Planning Office 1988.

The Over-Development of the Urban Sector

Similarly to the other Eastern Caribbean islands, the Leeward side of Barbados was the site chosen for the capital city and the urban sector in general.[16] Speightstown and Holetown, the two main settlements north of the capital, and Oistins, the main settlement to the south, were founded early in Barbadian history and, together with Bridgetown, formed a ribbon of urban development that would burgeon into the twentieth century. Recently the urban belt has extended to the southeastern-most parish of St. Philip, and in 1980, 62% of the total population, or 152,000 people, lived within the urban boundary (Town & Country Development Planning Office 1988). With the growth of Bridgetown as a chief

seaport, the capital's population mushroomed from 28% of the nation's total in 1844, to 42% in 1970 (Potter 1983a), and nearly 45% in 1990 (PAHO 1990).

Conversely, there has been a continuous population decline in the most eastern and rural parishes of Barbados. The move from the rural to the urban sector has mirrored the national transition from a predominantly agricultural producer to urban-based tourism and manufacturing. Potter (1983a, 1983b) observed significant socioeconomic disparity between the urban and rural sectors, noting more professional employees, car ownership, and higher income in the western and southern coastal parishes than in the eastern and northern ones. In 1980, 67-70% of all job opportunities were within the Greater Bridgetown area (Potter & Wilson 1989).

Inter-Migration and Changes in the Spatial Distribution

Figure 3-1 illustrates the changes of population in the 11 parishes over a 20-year period. In the Physical Development Plan of 1986, four major zones of population decrease were identified and found to be better indicators of shifts than the parish boundaries. The regions of decline include the following: (1) the sugar-belt region in the Christ Church ridge and St. George's Valley; (2) the Scotland District, excluding the Belleplaine area; (3) the western coastal strip from Speightstown to Oistins; and (4) the old sections of Greater Bridgetown (Town & Country

Development Planning Office 1988). Migration out of the sugar belt and Scotland District were primarily due to changes in the agricultural industry and the lack of alternative modes of production in those regions, while changes in the coastal strip were due to the marginalization of residential units by the tourism industry (Town & Country Development Planning Office 1988). The decline in the Bridgetown population represents the growth of suburbia and the quest for a higher standard of living. Similarly, suburbanization is largely responsible for increases in the northernmost coastal belt between Cave Hill and Speightstown, St. Philip, western St. George, parts of St. Lucy, and an eastern sector of Greater Bridgetown (Town & Country Development Planning Office 1988).

Demographic Decentralization and the Development of Suburbia

In keeping with the British urban decentralization ideology and in response to the piecemeal development of the urban sector, the Barbados Office of Town and Country Planning was established in 1959, following the Town and Country Development Planning (Interim Control) Act of 1959. The original objective of the Act was to control the development of the 3 to 5 km wide strip of land along the west and south coasts as well as the stretch of land on the east coast between the villages of Belleplaine and Bathsheba (Potter & Wilson 1989; Potter 1983b).

Following the Town and Country Planning Act of 1965 and Independence in 1966, the Chief Town Planner was given the task of preparing the physical development plans for the island, which included a hierarchical decentralization and rationalization plan, with services and projects radiating from the capital city, to regional urban centers, followed by district centers, and lastly village centers (Potter & Wilson 1989). In theory, the plan would assist in the economic and community development in areas poorly served in the past, as well as regulate the growth of the capital (Potter & Wilson 1989).

Potter & Wilson (1989) contend that the original plan of 1970 was "almost utopian" and not practical in the immediate future. A revised plan of 1983 recognized the unbridled process of suburbanization surrounding the metropolitan area, rather than the growth of planned settlements envisaged a decade before and redirected its energy toward the controlled development of an urban corridor stretching from the far northwest to the extreme southeast, thus integrating the already existing urban areas. In short, the 1983 plan clearly defined what is "urban," delineated an axis of urban growth and centers for expansion and identified rural settlements with the potential for growth (Potter & Wilson 1989). Figure 3-2 illustrates the demarcation for urban development and indicates areas for projected development.

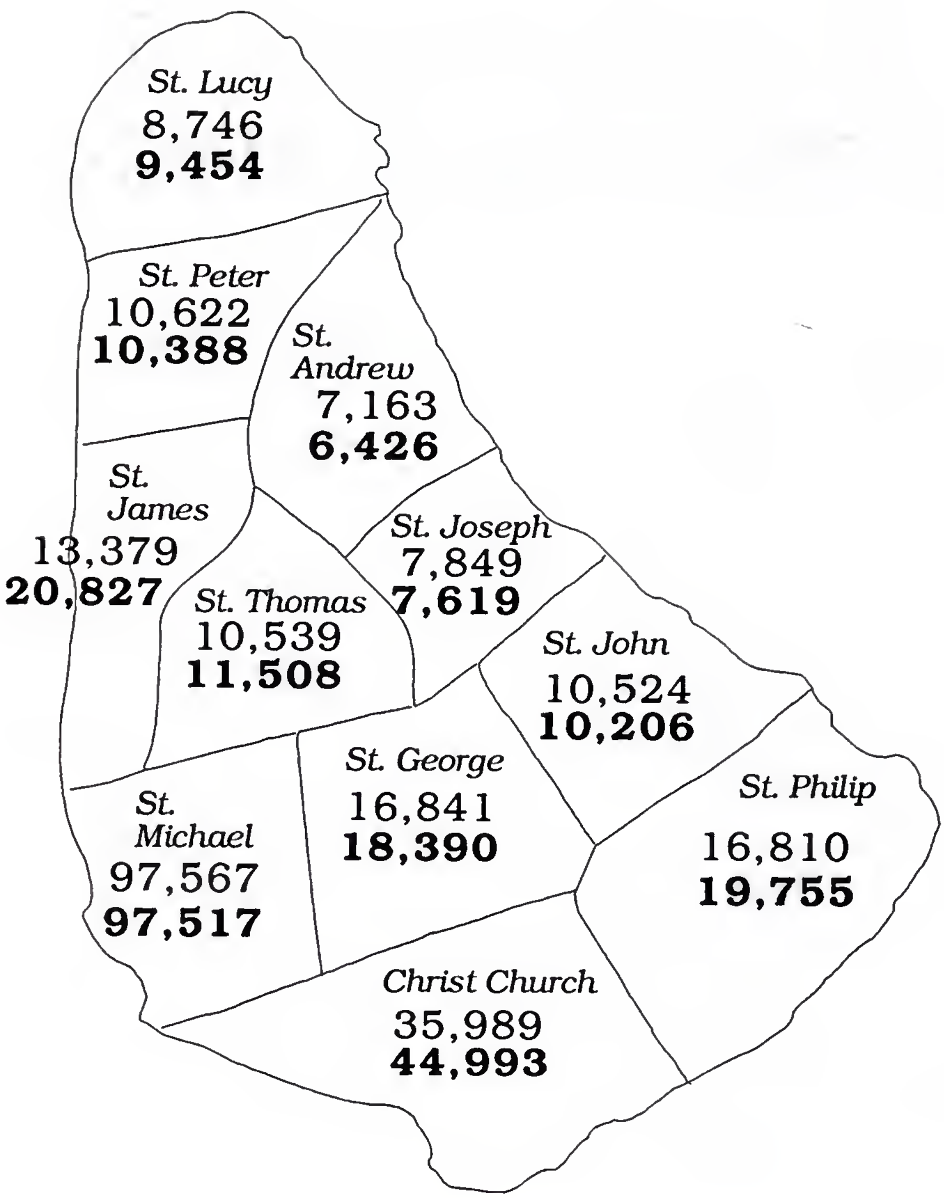


Figure 3-1. Inter-migration patterns by parish, 1970-1990. Source: Town & Country Development Planning Office 1988, 1990 Population Census (unpublished data).

Figure 3-2. Settlement and Land Use Policy of Barbados. The broken line indicates the urban/rural demarcation according to the Physical Development Plan of 1986. Reprinted with written permission from the Town and Country Development Planning Office. 1983, p.137.


SETTLEMENT AND LAND USE POLICY.
AGRICULTURE
REGIONAL CENTRE
NATIONAL CENTRE
CENTRE WITH RESTRICTED GROWTH
CENTRE FOR EXPANSION
SUBURBAN CENTRE
DISTRICT CENTRE
PREDOMINANTLY URBAN RESIDENTIAL
RURAL SETTLEMENT
RURAL SETTLEMENT WITH POTENTIAL GROWTH
CENTRAL PLACE ACTIVITIES
TOURISM AND RECREATION
MAJOR INDUSTRIAL AND/OR WAREHOUSING
MAJOR INSTITUTIONAL
MAJOR RECREATIONAL AND/OR OPEN SPACE
AREA FOR SPECIAL ENVIRONMENTAL CONTROL
POTENTIAL IRRIGATION AREA
NATIONAL ARTERY
WATER PROTECTION ZONE I
PRIMARY URBAN ROAD OR HIGHWAY
AIRPORT
SECONDARY URBAN ROAD OR HIGHWAY
LIMIT OF URBAN ZONE
PROTECTION OF CLAY RESERVE
NATIONAL PARK BOUNDARY
PROTECTION OF SAND RESERVE
AXIS OF URBAN GROWTH
PROTECTION OF SAND AND CLAY RESERVE
N
TOWN AND COUNTRY DEVELOPMENT PLANNING OFFICE.
MINISTRY OF FINANCE AND PLANNING
GOVERNMENT OF BARBADOS 1983
20

The concept of "sub-divisions" in Barbados is not a new one and, as Nurse (1983) explains, really began following emancipation, with the formation of village tenantries on plantations, situated on the "rab" land and inhabited by the growing peasant farming class. The government began regulating sub-division activities with the Public Health Act of 1908, for the purpose of managing the growth of already-existing tenantries, the development of waterworks, and determination of land value for tax and sales purposes, and in 1965, with the Town Planning Act, the Board of Health yielded these responsibilities to the Town and Country Planning Development Office (Nurse 1983).

In recent decades, Bridgetown proper has undergone a slight decline in population growth; percentage of the total population decreased from 41.76% in 1970, to 40.15% in 1980 (Potter 1983a). In view of the continuing decline of the rural population in the northern and eastern parishes, there is an apparent increase in the suburban sector. Between 1970 and 1980, the fastest growing parishes in terms of population and housing were St. James, Christ Church, and St. Philip, respectively (Town & Country Development Planning Office 1988). Table 3-2 illustrates the census findings over a 10-year period, indicating a slight decrease in the rural and urban sector and an increase in suburban sector.

Table 3-2. Percentage distribution of the Barbadian population by socio-geographic zone, from the Government Statistical Department Census for 1970 and 1980.

Zone	1970	1980
rural	33.4	32.2
suburban	25.2	27.6
urban	41.4	40.2

Source: Dann, 1984, p.24.

In recent years there has been an increase in the development of suburban sub-divisions in Barbados; sub-divisions are defined by the Development Planning Office as housing development areas of "10 or more lots" (1988, p.43). This increase appears to be an effort by land speculators to make a profit out of agriculturally idle land, a failing sugar economy, and to keep up with the demand of a landless population wanting to improve their standard of living. Their appeal to the higher income population is evident in the increasing size of the lots being developed; the majority of lots fall in the "greater than 10,000 square feet" range and there is an increasing number of homes with greater than five rooms (from 5,630 in 1960 to 15,169 in 1970) (Nurse 1983). There seems to have been an over-estimation in the demand for sub-divisions; from 1965-1977, only 55.8% of the lots developed had been sold and homes had been built on only 13% of the lots (Nurse 1983). A relatively large proportion of the land sold (21.5%) went to

overseas owners, presumably Barbadians living abroad (Nurse 1983).

Most sub-divisions tend to be located in only a few of the 11 parishes; 70% of the lots are situated in St. Philip, Christ Church, and St. Michael, which are in fact the parishes with the least rainfall and those areas most affected by drought, cane fires, and declining sugar cane production (Nurse 1983). They are also regions most accessible to the urban district. It should be noted, however, that a significant number of sub-divisions lie in the most fertile region of the country, particularly--and for reasons poorly understood--in the parish of St. George.[17]

Nurse concludes that benefits of the intense sub-division outweighed the costs, since the process provided improved housing stock in both quantity and quality, created employment through land development companies and service industries and served as a source of profitable investment (1983). Such benefits, however, appear to have benefitted only the wealthy; as a previous minister of housing from the opposition party noted, "...none of these poor agricultural workers who have given their sweat and tears for generations at Cottage Plantation would now be able to buy one square foot of that land which is being sold at a very high price: over $6 a square foot" (Clarke 1991, p.11A).

It is difficult to estimate the average cost of land in Barbados, since value depends on a number of factors. According to the Valuation Department, a small residential lot between 4,000 to 6,000 square feet probably costs $4.00-$7.00 per square foot (Hurley,[18] personal communication). However, tenantry land still sells for $1.00 per square meter and funds for financing purchase of tenantry land are available through the General Workers Loan Scheme and the Tenantries Loan Scheme (Town & Country Development Planning Office 1988).

One element in standard of living which has no doubt contributed to the development of suburbia in Barbados is the increase in private automobile ownership, which rose by 114% between 1966 and 1977 (Nurse 1983). According to the Chief Licensing Officer at the Ministry of Transport and Works, there are over 41,000 registered private vehicles in Barbados, plus 1,682 private motor cycles and 2,137 motor vans, comprising a total of 53,619 registered vehicles throughout the country (Broome,[19] personal communication). This element has afforded the wealthier Barbadians the option of moving out of the urban sector while maintaining their urban-based occupations. It has also changed the ideal of residential location. Proximity to work is less a priority than what is perceived as "a nice place to live." This is referred to as "going back to the village" and is

reflective of the American theme of "moving out to the country."

The Continuation of Tenantry Residency

Regardless of growth in the suburban sector, nearly one-third of Barbadian households are in tenantries; according to the Permanent Secretary of the Ministry of Housing and Lands, as of 1991, 30% of Barbadian homes (approximately 20,000 dwellings) were located in tenantries (Barrow,[20] personal communication). It has been estimated that 465 tenantries, previously on plantation land, are in the urban sector, primarily St. Michael (Town & Country Development Planning Office 1988). A breakdown of the spatial distribution of tenantries is illustrated in Table 3-3.

Table 3-3. Spatial distribution of tenantries by parish, 1990.

Parish	Number of Units	Number of Tenantries
St. Lucy	28	449
St. Peter	32	541
St. James	14	196
St. Andrew	11	297
St. Thomas	37	710
St. George	52	1,272
St. John	34	1,090
St. Joseph	22	395
St. Philip	49	1,023
St. Michael	10	309
Christ Church	27	597
Total	316	6,879

Source: Ministry of Housing & Lands. 1990, p.74.

The Physical Development Plan of 1986 outlined the following problems related to urban tenantries: (1) poor access and street layout; (2) absence of space for community and recreational activities; and (3) problematic shape and unacceptably small size (Town & Country Development Planning Office 1988). The Planning Office's minimum standard size for residential lots is 225 square meters (2,422 square feet) and 25% of these urban tenantry lots are smaller than the minimum standard (Town & Country Development Planning Office 1988). Many, in fact, are 1,000 square feet or less (Hurley, personal communication).

It would appear that little ground has been gained by the average peasant regarding land ownership, since only 2,557 plots had been purchased between the passing of the Tenantries Freehold Purchase Act in 1980 and December 1990; for the year 1990 alone, only 223 plots were purchased (Barrow, personal communication). However, since the average cost of rented land on plantation tenantries is a mere 10 cents to 25 cents per week (Barrow, personal communication), it is not surprising that tenants do not purchase the plot on which they live. Another incentive to continue renting rather than purchasing land is the fact that tenants have been protected from unreasonable rent increases on tenantry land since the time before the Freehold Act (1980), via The Security of Tenure of Small Holding Act (1955) and the Tenantries Control and

Development Act (1965). Also, although tenantry land is to be sold at $1 per square meter, when land tax is taken into account, there is little incentive to purchase the lot if income is a serious constraint.[21]

External overcrowding (distance from the nearest neighbor) is greater in the rural sector than in the suburban sector; there are an estimated 10,000 "small holdings" in the rural district of less than 5 acres of land, with an average size of less than half an acre (Town & Country Development Planning Office 1988). External overcrowding is highest in the urban sector (Dann 1984). While the typical lot sizes in tenantries average 3,000 square feet, private developers build on lots ranging from 4,000 to 8,000 square feet, depending on the location (Barrow, personal communication). From this statistic, one can infer that overcrowding is more of a characteristic of tenantries than suburban heights and terraces. "Overcrowding" is relative; the average height/terrace lot that is typically a maximum of 8,000 square feet seems almost small when one considers that one-quarter acre, a size that many suburban Americans probably enjoy, is over 10,000 square feet.

In summary, contemporary land tenure and distribution has changed in the twentieth century. The decline of the sugar industry and an increase in urban-based economies has fostered migration into the urban sector, a new phenomenon

in the scope of Barbadian history, since prior to the decline of sugar, overall residency was rural in nature (agricultural). With migration into the urban sector there has been an increase in urban crowding, and this factor has stimulated the growth of sub-divisions, or a "suburban" sector. Yet these housing developments have been aimed at the upper class and have done little to relieve the tenantry status of the working class. In fact, despite the glut of sub-divisions and passing of Acts aimed at increasing land ownership, a relatively small number of residents have purchased land. Nevertheless, a new econo-political order is in place, and presumably an increase in land ownership will continue and result in general up-grading of the domestic environment.

A Closer Look: Evolution of the Barbadian Home

In this section I will focus on perhaps the most controversial of the variables involved in the relationship between asthma and household pests, and that is the house itself, or rather, modernization of the house ("house" in this sense refers to any domestic dwelling). Certain aspirations in housing, once realized, will at least in part create an environment conducive to the proliferation of highly allergenic species of arthropods and other animals, collectively referred to in this thesis as household pests. These developments in housing, coupled with the meteorologic and economic conditions such as those found in a tropical,

developing country, challenge the traditional meaning of the term "modernization." Indeed, a rather paradoxical situation evolves: in an effort to better the living standards in a given culture, members have actually compromised their health status despite their achievements. Again, referring to the "epidemiological transition," we have observed this scenario time and again. No one would argue that dependable food supplies, conveniently available to all members in society, is beneficial and therefore a step towards "progress." But convincing the public that overnourishment is as dangerous as undernourishment (e.g., heart disease, obesity, diabetes) has proved difficult, and efforts to do so are compounded by the fact that chronic disease is often less impressive to the public than acute disease.

Traditional House Forms

Housing in the pre-emancipation period

The house form of the black slaves is surprisingly well-defined, despite the fact that only a few of those original structures still exist in Barbados. An archeological investigation by Jerome Handler reveals the following:

> ...throughout the slave period the most common type of house was something one doesn't see today and this was a house made out of organic materials, which we call wattle and daub. It was a small hut, made by inserting poles or posts vertically into the ground, and then inter-lacing the poles horizontally with vines or twigs so as to form a latticework; these latticed walls were then plastered with clay or mud...The roofs of these...were thatched with materials such as cane trash, palm branches, or plantain leaves...Houses were normally partitioned into two rooms, sometimes three...and it wasn't until late in the slave period that wooden plank floors were used... (1972, p.68).

Houses were crowded, sparsely furnished, and typically clustered into small villages, referred to as "the Negro yard", situated near the plantation yard, close to the planter's house (Handler 1972). Proximal to the Negro yard were garden plots, water supplies, and burial grounds. A German servant noted in 1652 that "...Around the plantation yard stand the slaves' small houses. These are made of inferior wood, look almost like dog-houses, and are covered with the leaves of trees that they call 'Blandin'..." (Gunkel & Handler 1970, p.92).

Towards the end of the slave period "stone huts" began to replace the wattle and daub huts, although most slaves still lived in the organic houses at the time of Emancipation. The stone huts, in fact, are believed to have been constructed mostly by indentured servants (Fraser et al. 1990). Hudson notes that these permanent structures often referred to as "slave huts" were the predominant house form in villages created out of plantations for freed slaves, indentured servants, and militia men who decided to

stay on in Barbados (personal communication). Sometimes these "slave huts" (perhaps a misnomer) were referred to as "trash huts," because they were roofed with trash; roofs were replaced with galvanized iron sheets in the twentieth century (Fraser et al. 1990). The stone huts were a relatively cheap solution to the flimsy nature of the wattle and daub huts of the slaves, as coral limestone could be quarried anywhere in Barbados. The addition of a low hip-roof (with slopes on all four sides) made the stone hut considerably more resistant to tropical storms and hurricanes than its wattle and daub predecessor (Fraser 1990). Their rarity can be accounted for by the land tenure practices of their time; being constructed of stone, they were permanent fixtures and necessitated tenure of the land. Yet only a small population of landowning peasants at that time held long-term titles to land. Uncertain land tenure resulted in a much different house form--the chattel house.

Emancipation and the chattel house

A new phenomenon in housing emerged following emancipation--the development of the chattel house. The chattel house would become the most prominent of house-types in Barbados and would dominate until the late twentieth century. The word "chattel" means, literally, a moveable, personal possession. The most significant attribute of the Barbadian chattel--and the reason for its predominance--was its moveability. As previously described, due to the

tenuous status of residency on plantation tenantries, it was necessary for workers to move their few possessions and their family with little warning and immediately upon notice. With the chattel, the house could be taken apart and loaded onto an oxcart within hours, moved to another tenantry, and reconstructed.

Style and construction. The origin of the style of the chattel is both south English and West African; according to Potter (1989), folk houses in both environs were rectangular in shape (a ratio of 2:1), typically two-roomed, a symmetrically placed main door on the long wall, and a gabled, thatched roof. This style was conducive to expansion; additional units could be constructed behind the front unit. Throughout the Caribbean, the structure was raised off of the ground, supported by lose rock piles, to minimize the effects of insects, such as ants, termites, and rodents, and to allow for ventilation. The rock pile foundation had the added advantage of being relatively sturdy, low cost, and dispensable in the event that the house was moved. An additional climatic adaptation in the development of the chattel was the orientation of windows and doors with respect to prevailing winds (Potter 1989).

Windows come in a number of styles. The traditional window is either the Demerara window[22] or the wood jalousy, or louvre, though glass panes are common, usually in panels that "swing" out. Currently, more common than the wood

jalousy is the glass louvre window, identical in principal but improved in durability, and glass louvres have the added advantage of allowing light into the room even when closed.

The "tray" ceiling was designed out of practicality for ventilation purposes; the roof is sealed at one to two feet above the level of the walls, giving it the appearance of an "inverted tray with sloping sides" (Fraser 1990, p.86). In many instances, there is no ceiling at all, allowing for ventilation and the exchange of fresh air in and out of the gaps between the roof and wall. The chattel roof was usually either the sloping, pitched gable type, clad with wood shingles and nailed down, or "hip", relatively resistant to hurricanes and ideal for ventilation.

A variety of decorative touches add to the charm of the Bajan chattel. Fretwork barge-boards decorate gables and pedimented porches, and bell pelmets (bell-shaped hoods), shade the windows. Fraser (1990) notes that porches are "a very English thing," although of practical value, and are rarely found in the folk architecture elsewhere in the Caribbean. A common practice used to give an enlarged appearance to a chattel is to add a veranda to the structure (Fraser 1990); Potter (1989) notes that the incorporation of Georgian[23] verandas and terraces is also uniquely Barbadian, although Georgian architecture in general has been incorporated into other Eastern Caribbean house forms. Technically a veranda enclosed by jalousy windows is a

"gallery," and considered a separate room, but it is common for Bajans to refer to any porch or veranda as a "gallery," a characteristic that denotes pride and status, in that such an elaboration exists and could be afforded in the first place (personal observation).

Houses are painted in a variety of bright or pastel colors, typically trimmed in white, and fresh coats are replaced frequently, usually during the Christmas season after receiving the "Christmas bonus," and in preparation for holiday guests.[24] Decorative horticulture in the front of the house, incorporating a variety of tropical plants, (e.g., hibiscus, oleander, and poinsettias), is reputedly an "English" tradition (Fraser 1990); at the least, it is a source of pride that requires minimal financial investment on the part of the householder (due to the favorable climate), yet yields as much attention as a fresh coat of paint. Interestingly, all of the attention and care is given to the front of the chattel, not unlike the interior of the house (to be discussed), and the sides and back are typically enclosed in unkept "pealing" (corrugated iron sheets), with little attention to vegetation.

Another Bajan tradition is the naming of one's house. As one editor lamented, "Nowadays with all these heights and terraces we live in, some houses are beginning to carry numbers. I really hate it. It all seems so impersonal to

find someone by the number on their house" (Hoyte 1991, p.11A).

Spatial distribution. Significant changes were made in the spatial distribution of housing following emancipation. As described, slave quarters were situated close to the factory yard and planter's house during the pre-emancipation period. However, following emancipation, tenantries were moved to the rab lands, or outskirts of the plantation, as far away as possible from factory yard. Hughes[25] contends that both groups--the white planters and the black freedmen--preferred this arrangement, to be as far away as possible from each other (personal communication). Secondary to the placement of tenantries on the marginal plantation rab lands--marginal both in size and in quality of soil--tenantries took on a somewhat "urban" characteristic because of crowding. As Lowenthal aptly depicted:

> ...The villages, which focus around crossroads where a few shops, a street lamp, and maybe a chapel are to be found, are extraordinarily compact; houses touch, or almost touch, and many have only a few square yards for a yard or a garden. This extreme degree of clustering, together with the tendency of the people to place their houses directly on the highways, sometimes gives one the impression that Barbados is a continuous village. (1957, p.471-472).

Other house forms and modifications of the chattel house

Until recently the typical Bajan home was represented by one of four general prototypes. The chattel house was the most common by virtue of the fact that the majority of the population was landless. Other house forms included the

West Indian plantation great house (primarily constructed of coral limestone and Georgian in design), the suburban villa (also constructed of coral limestone), and the urban town house. All forms were shaped by the influences of sociopolitics, economy, the availability of building resources, and climate.

While the chattel house evolved for pragmatic reasons--suitable for the tropical climate and for the insecure nature of the tenantry system--it is truly a vernacular art form. If the <u>structure</u> emerged from the tenantry system, the <u>style</u> emerged out of the Georgian architecture of the larger suburban and plantation houses. It would appear that, rather than eliminating certain architectural features from the construction of a house, builders in the lower socioeconomic strata simply scaled down features, so as to replicate the architectural pattern of the planters and merchants--the island elite. This contention is supported by the presence of symmetrical facades, hooded windows and jalousies, gables, porticos and verandas, as well as the countless decorative touches, such as barge boards and French doors.

Fraser & Hughes (1986) explain that the architectural pattern of the planters was very much dependent on the financial state of the island throughout Barbadian history. Richard Ligon, who wrote the well-known "True and Exact History of the Island of Barbadoes" in 1657, was appalled at

the hasty means by which the planters of the early years erected their homes and their lack of consideration for ventilatory principles (Fraser & Hughes 1986). Gosner explains that the earliest West Indian homes in general reflected a working class' interpretation of the folk architecture of their native home, rather than the Renaissance ideals of the gentry (1982). Indeed, the first residential dwellings were first "make-shift", followed by a simple medieval style copied after their own in Europe, though completely unsuitable for the tropics due to its emphasis on "the vertical" and small windows (Gosner 1982).

With the incorporation of the Georgian style--and a re-interpretation of that style to fit the Caribbean--architectural practices were increasingly better suited for the warm and humid tropical environment. Fireplaces and chimneys were eliminated, except in the outdoor kitchens, and to allow for maximum time spent outdoors in the shade, galleries and verandas were used as dining and living areas (Gosner 1982). Status was sacrificed for economy and improved ventilation and the heavily-taxed glass windows were largely replaced with louvres (Gosner 1982). Although the landless proletariats were limited to light-weight, movable timber for their homes, the plantocrats took advantage of the abundant coral limestone and constructed structures virtually impermeable to tropical storms and even hurricanes, as well as insects such as the termite. Storm

shutters, low hip roofs, and a maximum of two levels plus a basement added to the hurricane-resistant design.

Town houses were the merchants' version of the Great House. These urban structures provided space for the business on the ground floor and housed the merchant and his family upstairs. They were borne of a central urban environment, characterized by narrow streets and oddly-shaped lots. Because they were located at the center of international trade and the headquarters for the European power, they were cosmopolitan in nature and depicted the least "national" traits of house forms in the colony (Gosner 1982). As Gosner explains, referring to Caribbean townhouses in a general sense, the West Indian townhouse "owe[s] something to the shop-dwellings of Spain's Mediterranean seaports; the graceful iron balconies are French in inspiration; [and] the arcades go back to Italian Renaissance cities..." (1982, p.22).

An outgrowth of the urban town house was the suburban vernacular house, a response to a burgeoning primate city in the nineteenth century and the need to devote maximum space to commerce in the urban sector. Fraser & Hughes summarize its design as follows:

> ...perfect symmetry, both in external walls, gables, decoration and floor plan; a low, hurricane resistant, rectangular shape; a front gallery usually enclosed by serried ranks of wooden jalousy windows and Georgian glass sash windows; a central front porch with a small pediment supported by "turned" wooden posts adorned with delicately carved friezes and sometimes wooden tracery; a double staircase approaching the porch with the principal rooms on an upper level in larger houses; a stone parapet staircase separating the roof of the front gallery from the gable behind it... (1986, p.60).

The primary objective of the suburban design was coolness (fostered by gable roofs, jalousies, and living rooms on the first floors), but many of the details were purely for aesthetic purposes. With the continued development of suburbs into the twentieth century, the suburban vernacular style continued and was in fact gradually incorporated into renovations of the plantation Great Houses and into the design of upgraded chattels. Like the chattel, this vernacular house form is believed to be unique to Barbados (Fraser & Hughes 1986), and it appears to have been influential in the design of the "single house" of Charleston, South Carolina.[26]

Acworth contends that by 1840, Caribbean architecture in general was well-developed and each island was incorporating its own vernacular art form into residential construction:

> ...Though still looking for inspiration from England, the Islands had each of them developed building habits of their own and had, indeed, gone far towards establishing an architectural tradition. Shingles and fish-scale tiles, timber and brick, cut-stone and Spanish-walling, windows and jalousies, hoods and solid shutters, gave ample scope for variety in architectural treatment; and each island had by this time made its choice. The choice was not altogether a free one--it was conditioned by the availability and relative cheapness of materials as well as by the circumstance of geography. but there was still plenty of room for the play of fancy; and, by and large, the colonists made good use of their opportunity... (1949, p.35).

In summary, the Georgian style of architecture was integrated into the Barbadian house form almost immediately after colonization. At least among the lower socioeconomic strata, West African traditions were probably incorporated as well. The style was an adaptation to the tropical environment and different types of structures reflected the financial means of the class for which they were built, via size, materials of construction, and spatial distribution (e.g., the small, timber chattel for the working class, the stone great house for the planter). Emulation and imitation of the upper strata house form is evident in the design and detail of the working class chattel; this suggests that the "ideal" house form has always been one constructed of a permanent material (stone), relatively large, and most importantly, constructed on a piece of property that was <u>owned</u> by the householder. Alternatively, it could be that the desire to own land--and to exploit that ownership by constructing a dwelling that expresses ownership (a concrete

or stone house)--supersedes what is actually preferred at the structural (architectural) level. This suggestion indicates that "modernization" of the home has less to do with the desire for particular features in the domestic environment than does the social status associated with modernization and that a much greater force than convenience is operating in the evolution of the home.

Trends in Contemporary Housing

The Role of Ownership

Perhaps because of the symbolic importance that home and land ownership has played in the social history, housing has been a volatile political issue throughout much of the twentieth century. As reported by The Advocate,

> housing is dear to the hearts of all Barbadians, and to own one's home is probably the single most attractive goal shared by this country's nationals. Barbadians have a long-standing reputation of being house proud and even the most humble chattel dwelling is a source of pride to its owner... (Thursday, June 17, 1982).

The etiology of the imbalance between land ownership and home ownership has been discussed. As was presented, even legislation that enables tenants to purchase land is only benefiting the working class at a slow pace. No doubt the delay in what was predicted to be a housing development boom can be attributed to the economic crisis of the past 2 decades. Nevertheless, the stage is set for significant

changes in Barbadian housing, and some of those changes have already taken place.

Increasing rates of land ownership, or at least intent for land ownership, are evident in three housing trends: (1) a decrease in the incidence of housing relocation; (2) the increasing integration of concrete into previously all-timber structures, or the construction of new, exclusively concrete structures; and (3) the increase in installation of plumbing and utility provisions. All three of these factors demonstrate an element of permanency and, in theory, should ultimately lead to an improvement in the overall standard of living. Not unrelated to the three trends is the elevation of self-esteem and pride and the sense that the average Barbadian is finally overcoming the historically-based social stigma of a landless proletariat.

Certainly a situation in which a tenant has virtually no latitude for home improvement is one in which both the dwelling and land are rented. Therefore, it comes as no surprise that apartment living is unattractive to Barbadians, despite the appeal among Barbadian youth for materials and practices that are "Euro-American." As Graham Dann[27] notes, "...it's the 'house being your castle' idea" that deters even the young Bajans from apartment residency (personal communication) and therefore strengthens the extended family living pattern. Furthermore, most of the apartments for rent in Barbados are priced and marketed with

tourism in mind and rent is subsequently beyond the means of most Barbadians (personal observation).

A form of rental that is prevalent out of necessity rather than preference is low income housing; 4,048 Barbadians lived in low income housing apartment or housing units provided by the government in 1991 (see Table 3-4 for breakdown by parish) Babb,[28] personal communication). W. Babb of the National Housing Corporation (NHC) reported that the profile of the average renter was as follows: the average tenant is female, 25 years old, usually employed as a domestic servant, and earns approximately $150.00 weekly (Babb, personal communication). The NHC reported that the average two-bedroom unit cost $20.00 per week, and a three-bedroom unit cost $30.00 per week (1991) (Daisley,[29] personal communication).

The Town and Country Development Planning Office reckoned a need of approximately 1,700 dwellings annually between 1980-1985 to account for the following: "(i) Formation of 440 new households per year; (ii) [r]eplacement of 75 units lost annually in fire and 20 units lost due to change of land use; (iii) [and the n]eed to build 1.8% of the stock or 1,209 units annually due to the accumulated back-log demand to replace obsolete temporary structures,..." (1988, p.45). However, as of 1981, the Ministry of Housing and Lands only had 4,000 units to accommodate the greater than 10,000 applications that had

been back-logged for 11 years (Dann 1984); note that the reported "4,000 units" of 1981 are not significantly different from what was available 10 years later, at 4,048 units.

Table 3-4. Tenants living in National Housing Corporation units by parish, 1991.

Parish	Number of tenants
St. Michael	2,813
Christ Church	669
St. Thomas	52
St. Peter	36
St. Andrew	29
St. John	18
St. Philip	38
St. James	337
St. Joseph	15
St. George	41
Total	4,048

Source: National Housing Corporation, unpublished data for 1991 (Babb, personal communication).

Nevertheless, the majority of Barbadians enjoy a very high degree of home ownership--47,124 (70.2%) households in 1980 owned their dwelling (Potter 1989). There is notable disparity between home ownership from district to district varying from 24.7% to 98.0% (Potter 1988). There is also a general decline in home ownership with the degree of urbanization and along the urban south and west coasts (Potter 1988). Table 3-5 illustrates the breakdown of dwelling tenure by parish for 1980, demonstrating the disparity of ownership by region; heavily urbanized St.

Michael shows the lowest percentage of ownership and rural St. Andrew, St. Joseph, St. John and St. Lucy show a very high percentage of ownership.

<u>A decline in relocation</u>

As previously defined, the chattel house was originally constructed in a manner in which it could be dismantled within hours, loaded onto an ox-cart (later, a flat-bed truck), relocated and reconstructed, all in the same day. M. Hurley at the Valuation Department recalls: "...When I was a boy, every Sunday morning you saw them moving on trucks, big trucks" (personal communication). The houses are dismantled in sections and walls and gables are stacked on top of each other, then pieced back together at the new location. The coral rock pile is left behind and another one is created at the new site.

The rate of relocation is declining annually. In 1980, 700 chattels were moved, mostly from the rural to the urban sector (Potter 1986; Town & Country Development Planning Office 1988) and in 1989 the number of relocations was 636; this figure was up slightly from 1988, in which 580 dwellings were moved (Ministry of Housing & Lands 1990). Table 3-6 demonstrates the trend in relocation by parish over a nine-year period. Relocation is viewed as a sign of home improvement, since two of the reasons given for relocation are the change in status from tenant to owner and

participation in development projects and urban renewal (Ministry of Housing & Lands 1990).

<u>Upgrading the chattel and creating new forms</u>

A somewhat standard, step-wise process of development in the contemporary Barbadian home has been described in the literature (Potter 1989; Fraser 1990; Fraser et al. 1990) and can readily be observed in Barbados. The "typical" chattel is approximately 10 by 20 feet (3 by 6 meters) and divided by a partition into a living area and sleeping room. This is reminiscent of the medieval house plan, or "hall-and-parlor," 2-room plan, in which two rooms were side-by-side, with an entrance relatively centered on the long wall, leading into the larger of the two rooms (Gosner 1982). Typically there is a 6-12 inch space between the partition and ceiling, if there is a ceiling. In most of the simplest chattels the rafters are exposed, and if a ceiling is present, it is only in the front living area.

With an increase in family size or availability of capital, the household may decide to upgrade the chattel, creating more space. Potter (1989) has defined the upgrading of a wooden chattel as follows: the addition of a unit (including a second bedroom and separate dining area) to the back of the house creates a "bipartite chattel." The construction of yet another unit, affording a third bedroom and subsequently a separate kitchen, dining, and living room, is referred to as a "tripartite chattel" (Potter

1989). This last unit to be added is also referred to as the "shed roof," probably because, historically, it was not raised off the ground, as in the case of the front units, it was typically smaller than the other units, and it was covered with a sloping, flat roof rather than a gable or low hip-roof. It housed--and in many cases continues to house--the kitchen and an informal dining area. In the event that ownership of land is secured, the family may add a concrete toilet, shower and kitchen behind the front units, replacing the shed roof, or, if and when the capital is available, they may build an entirely new concrete structure around the old wood structure, then gut the wood when the new exterior is completed. A household may purchase the concrete blocks in increments, when cash is available, over a period of several years. Actual construction may take place in increments as well. Figures 3-3a-c illustrate the layout of the traditional chattel, the "tripartite chattel," and the modified chattel with concrete additions in the back of the house. Figures 3-4a-c illustrate the exterior appearance of this step-wise progression of the chattel.

Table 3-5. Dwelling tenure (owned, government rental, or other) by parish, 1980. "Other" status includes rental, rent free, squatted, and not stated. Figures given as both frequency and percent of the total for each parish.

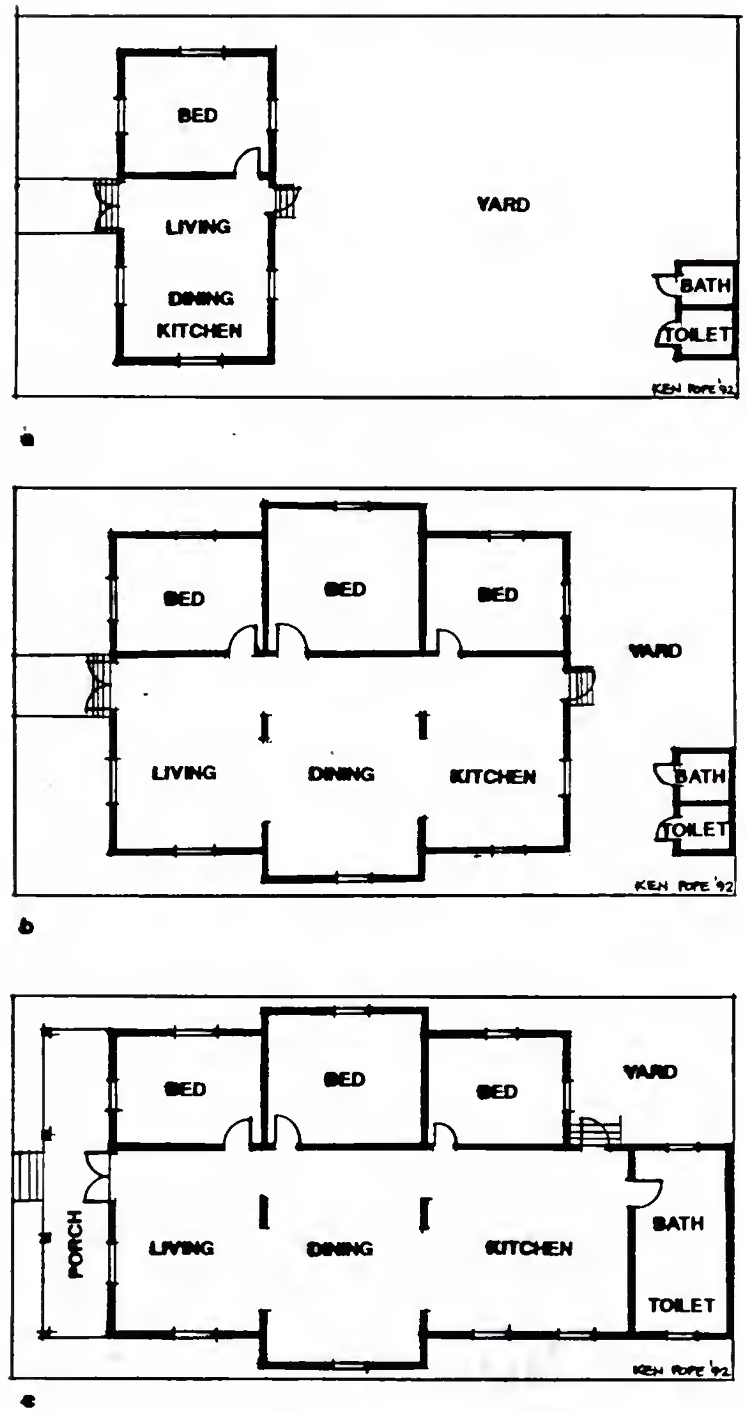
	Owned		Government rented		Other		
Parish	Frequency	Percent	Frequency	Percent	Frequency	Percent	Total
Christ Church	7,544	66.63	505	4.46	3,273	28.91	11,322
St. Philip	3,940	82.41	56	1.17	785	16.42	4,781
St. John	2,133	86.95	22	0.90	298	12.15	2,453
St. George	3,593	84.52	45	1.06	613	14.42	4,251
St. Joseph	1,426	81.86	52	2.99	264	15.15	1,742
St. Andrew	1,396	88.02	35	2.21	155	9.77	1,586
St. Lucy	2,025	84.80	2	0.08	361	15.12	2,388
St. Peter	2,313	81.99	4	0.14	504	17.87	2,821
St. James	3,455	72.17	237	4.95	1,095	22.87	4,787
St. Michael	17,024	60.17	2,300	8.13	8,971	31.71	28,295
St. Thomas	2,275	83.89	58	2.14	379	13.97	2,712
Total	47,124	70.19	3,316	4.94	16,698	24.87	67,138

Source: 1980/1981 Population Census 1985.

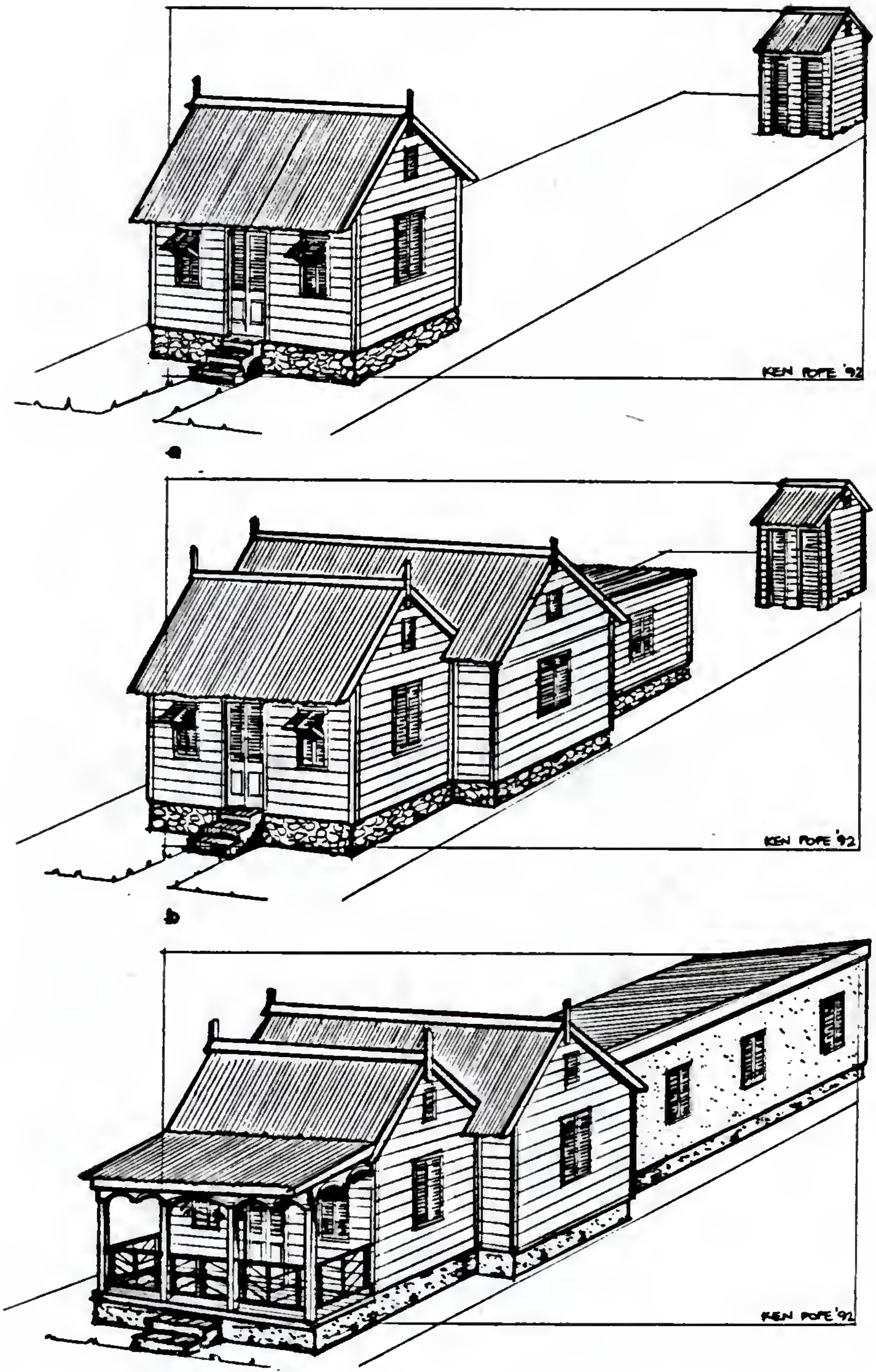
Table 3-6. Number of houses relocated by parish, 1981-1989.

Parish	1981	1982	1983	1984	1985	1986	1987	1988	1989
Christ Church	119	97	95	85	83	81	74	91	91
St. Philip	67	65	46	39	63	42	38	44	61
St. John	30	30	31	26	43	29	30	27	46
St. George	68	50	53	52	34	62	61	57	62
St. Joseph	15	11	11	21	24	25	26	28	27
St. Andrew	20	20	31	16	13	15	15	21	23
St. Lucy	17	19	36	31	30	23	40	38	35
St. Peter	41	29	42	48	15	31	33	30	34
St. James	53	51	50	44	55	57	45	41	45
St. Michael	167	222	179	182	182	157	168	171	167
St. Thomas	45	31	34	32	36	37	40	32	45
Total	642	625	608	576	578	559	570	580	636

Source: Ministry of Housing & Lands. 1990, pp.63-65.



Figures 3-3. Chattel house floorplan. (a) traditional chattel house; (b) tripartite chattel house; (c) modified chattel house with concrete addition.



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Figures 3-4. Sketches of the three stages of the chattel house. (a) traditional chattel house; (b) tripartite chattel house; (c) modified chattel house with concrete addition.

Somewhere between the traditional chattel house and the suburban villa emerged an intermediate house form, which the author refers to as a "modified chattel." These homes probably make up the largest proportion of structures classified as "wood and concrete together" in the census report. Fraser gives brief attention to these "wooden suburban" structures, which he also refers to as a "chattel house of stone", noting that the only difference between these newer structures and a chattel is that they are not movable, since they typically rest on a concrete foundation rather than loose rock, at least in the front portion of the house (1990, p.13).

But the modified chattel is different from the traditional house form in a number of features. It bears much less respect for symmetry in its design and incorporates a mixture of that which is traditional and that perceived as "modern." Not unlike its predecessor or any of the other Bajan house forms, it also presupposes access to certain materials, in regards to cost and availability. Again, this strikes a familiar chord with the medieval folk house counterpart, which was dynamic rather than static, not created as a single entity, but grew with the addition of ells and wings, resulting in an asymmetrical, irregular form, that did not bother the medieval builder in the least (Gosner 1982). Thus Bajans have come full circle, from first evolving their own vernacular art form of housing

based in part on what was architecturally sanctioned for the period--the Georgian--but modified to fit the climate and resources. Currently, at the end of the fourth century of their existence, the process is continued by recreating the haphazard style of the late twentieth century under new social and economic circumstances. Nevertheless, architectural appreciators lament:

> in recent years appreciation of both the chattel house, the suburban vernacular and everything in between appears to have been lost, [since] [t]he symmetry, the gables and the decorative carvings are disappearing as these houses are destroyed and replaced by crudely designed houses that are purely utilitarian yet without the thoughtful and valuable features of the traditional house (Fraser & Hughes 1986,p.70)

The transition from wood to masonry

In the 1950s, nearly 90% of all homes in Barbados were built entirely from wood (Lowenthal 1957). According to Dann (1984), little had changed since the 1891 and 1921 censuses, in which 86.6% and 83.2% of the homes were reportedly of wood, respectively. In 1970 that figure fell to approximately 75% (Dann 1984), and in 1980, just over half (57%) of the homes were built entirely of wood (1980/1981 Population Census 1985).

As Potter (1989) explains, the national figure for the number of all-wood dwellings is deceiving, since there are in fact marked spatial variations; in one urban enumeration district, all-wood dwellings made up 91.2% of the total housing stock. On average, however, the rural parishes have a larger proportion of timber homes than the urban and

Table 3-7. Number and percentage of dwellings by type of material, for each parish, 1980.

Parish	Wood		Masonry		Mixed		Other		Total
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	
Christ Church	5,269	46.5	4,549	40.2	905	8.0	599	5.3	11,322
St. Philip	2,933	61.3	1,072	22.4	548	11.5	228	4.8	4,781
St. John	1,671	68.1	294	12.0	368	15.0	120	4.9	2,453
St. George	2,674	62.9	801	18.8	590	13.9	186	4.4	4,251
St. Joseph	1,241	71.3	166	9.5	260	14.9	75	4.3	1,742
St. Andrew	1,293	81.5	112	7.1	139	8.8	42	2.6	1,586
St. Lucy	1,635	68.5	427	17.9	217	9.0	109	4.6	2,388
St. Peter	1,888	66.9	397	14.1	348	12.3	188	6.7	2,821
St. James	2,344	49.0	1610	33.6	629	13.1	204	4.3	4,787
St. Michael	15,707	55.5	7,690	27.2	3,530	12.5	1,368	4.8	28,295
St. Thomas	1,822	67.2	446	16.4	274	10.1	170	6.3	2,712
Total	38,477	57.3	17,564	26.2	7,808	11.6	3,289	4.9	67,138

Source: 1980/1981 Population Census. 1985, p.174-193.

"suburban" parishes; Table 3-7 depicts the distribution of dwellings according to "material of construction." Not surprisingly, the parishes with the fewest number of timber homes are suburban Christ Church and St. James, at 46.5% and 49.0%, respectively, while the highest number of timber homes are in remote St. Andrew and St. Joseph, at 81.5% and 71.3%, respectively. Looked at from another perspective, for the same year, 1980, the number of households that applied for and received approval for renovation of their dwelling were overwhelmingly from urban St. Michael (Table 3-8). Similarly, the parishes with the greatest number of sub-divisions, Christ Church, St. George, and St. James, underwent a good deal of renovation also. "Renovation," of course, likely represents the addition of concrete to the existing structure.

Table 3-8. Applications approved by the Town & Country Development Planning Office for renovation of dwelling units, by parish, 1980.

Parish	Number	Percent
Christ Church	19	12.9
St. Philip	6	4.1
St. John	2	1.4
St. George	10	6.8
St. Joseph	1	0.7
St. Andrew	6	4.1
St. Lucy	1	0.7
St. Peter	8	5.4
St. James	14	9.5
St. Michael	75	51.0
St. Thomas	5	3.4
Total	147	100

Source: Ministry of Housing & Lands. 1990, p.38.

Table 3-9 presents the number of applications approved by the Environmental Engineering Division of the Ministry of Housing and Lands for new dwellings and the number of applications for renovations on existing dwellings, over an eight-year period. From the figures it is apparent that the majority of households, upon deciding to build an entirely new home, are building in concrete exclusively. It is interesting that, while the number of renovations on concrete homes and the construction of new concrete homes has steadily increased, the construction and renovation of exclusively wood homes seems to have peaked and is now tapering off. These data presented from the three tables indicate an overall trend in construction of masonry dwellings, particularly in the more densely populated regions of the country and in the regions with access to better resources. Based on policies from the Town & Country Development Planning Office and the shift in the population to the western parishes, there appears to be little incentive for residents in the very rural regions to upgrade their homes (note: data were not available from the final 1990 census and therefore could not be included in the review).

According to various building contractors, the estimated life span of a wood home in a tropical climate is roughly 20 to 30 years. Nurse (1983) suggests that one reason for the boom in land acquisition and construction

during the 1960s and 1970s was the fact that, according to the 1970 Census, 49% of the homes were 20 years old and over, thus creating a need for home improvement, or new construction altogether. There is institutionalized dissuasion against the use of wood in home construction by both the loan agencies, which limit mortgages on timber structures, and by developers, who restrict the use of wood in their sub-divisions by creating building standards that favor concrete (Nurse 1983). In addition, homeowners' insurance for wood structures is higher than for concrete structures because of the hazard of fire (Edghill Associates, Ltd.,[30] personal communication). For example, since in 1989, 43 of the 64 homes completely destroyed by

Table 3-9. Number of new and renovated dwellings by house type, approved by the Environmental Engineering Division, Ministry of Housing & Lands, 1982-1989.

	New Dwellings				Renovated Dwellings			
Year	Wood	Masonry	Mixed	Total	Wood	Masonry	Mixed	Total
1982	2	1,111	5	1,118	8	141	23	172
1983	7	1,056	19	1,082	10	203	43	256
1984	49	1,083	54	1,186	11	290	43	344
1985	30	519	30	579	47	203	59	309
1986	89	810	181	1,080	176	397	85	658
1987	232	1,824	366	2,422	209	565	421	1,195
1988	110	1,301	291	1,702	40	459	310	809
1989	80	1,851	195	2,126	82	711	149	942

Source: Ministry of Housing & Lands. 1990, pp.32-34, 46-48.

fire between 1989 and 1990 were timber (Ministry of Housing and Lands 1990).

A "wall" home ("wall" is colloquial for concrete) is to a degree an unspoken symbol of wealth, since only wood homes can be built on rented property. But concrete homes are also perceived as being better-built and are therefore preferred. "Mr. King" of Chalky Mount, St. Andrew, explains: "...a wall house is more expensive, but ya do not have to do anything to it. A wood house ya have to paint ev'ry year an' board it up. People prefer a wall house over board--it last longer. But, ev'rybody cannot afford it! On hills, ya can't build a wall house--it too hard." Thus the peasant landowners of the rural parishes are constrained by cost and topography in upgrading their homes.

There are some members in Bajan society who consider a well-built wood house to be of greater value than a concrete house and, depending on the type of timber, the wood house can actually be more expensive. A Bajan surveyor noted the following:

> wood houses can be as nice and more expensive than wall houses. You can have pine which is very cheap, usually imported from Canada, or you can have yellow heart or purple heart--that's very expensive, imported from Guyana. But it lasts. Termites can't touch it.

Early decimation of the rain forest and cane monoagriculture resulted in a scarcity of wood and necessitated the continuous importation of this material

throughout Barbadian history. In the late 1980s the Arawak Cement factory, jointly owned by Barbados and Trinidad and Tobago, commenced operation, followed by the opening of two cement block companies and a company producing the galvanize sheeting. As a result, Barbadians have greater access to sturdy raw materials than they did in the past. Curiously, greater access does not necessarily mean cheaper prices; in fact, a common complaint, in the words of a particular building contractor, is that the Arawak plant "[has] made concrete more expensive! It use to be they could import the cement from other Caribbean countries for a lot less money. The Arawak Company is government-owned though, and we have to buy from them, and they charge more".

Little has changed in the overall construction of chattel houses from the earliest building techniques, with the exception of the fact that one can purchase "pre-fab" chattel walls from building construction suppliers, and chattel builders frequently use correlated zinc-coated iron sheets, which Bajans refer to as "pealing", for the gabled, shed, or low hip-roofs. Galvanize is also used on the roofs of masonry homes. A new type of galvanize is called "permaclat," which is supposedly sturdier. The optimal and newest type of roof is called "closed board ceiling," and is one in which the exterior is covered in clay tiles, or shingles, and the interior is finished with ceilings of wood

planks, close together, and attractive enough that ceiling panels are not necessary (personal observation).

Window styles have changed considerably, largely influenced by a building supply company that seems to have a monopoly on the island. Window preference has transformed from the wood jalousies to substituted glass louvres, to the three- or four-pane awning windows (simply referred to as "Oran," after the company that produces them, Oran Ltd.[31]), to the currently popular aluminum sash windows with screens. But these darkened sash windows are preferred more for aesthetic purposes than for practicality:

> in the newer houses you see screens, but people really don't like them. Cuts down on the breeze, ya see. I saw one brand new house...the family moved in and just tore out all of the screens! You really don't need screens here...Besides, we have clean mosquitoes.

One tenant stated that, in her "dream house," she would prefer the aluminum sash windows with screens, because "they look so sexy." As a rule, nowhere except in the tourist apartments and hotels can one find screened windows in Barbados (personal observation).

The problem of construction in the informal sector

In the Sunday Advocate, it was noted that the old "timber house," or chattel, was built with the most reliable architecture in mind in regard to roofs and tropical weather (Greenidge 1991). In short, the low hip roofs and high gable roofs--ideally with a pitch of 30 to 40 degrees--have

a lower windload than the increasingly popular flat roofs and were better at withstanding serious storms. The editor noted that the faulty trend in architecture is attributed to "do-it-yourself builders" and small contractors who are increasingly involved in the building of private homes (Greenidge 1991).

Notice was given to the increasingly scant attention paid to practicality in architecture with the advent of the concrete home in the late 1950s. One observer, in his discussion of the grace, quality, endurance, and ventilatory principles in the traditional Caribbean Georgian style noted:

> The pleasing quality of this architecture bears no comparison with the houses or, more often, bungalid excrescences erected today whose thin walls, steel windows, low ceilings and verandas supported by pillars unknown to any order of architecture, offer neither shady nor cool rooms and whose protection from hurricanes is somewhat doubtful. (Connell 1959, p.172).

Although in theory the architecture of the wooden chattel may have been superior to the modified concrete versions of contemporary Barbados, attention must be given to the fact that, in the hurricane of 1955--the most recent of truly devastating hurricanes to hit Barbados--more than 1,000 chattels were completely destroyed and 15,000 were seriously damaged (Lowenthal 1957).

Fifty-two contractors are listed in the 1991 Barbados telephone directory. There are no statistics available to

determine what percentage of the population relies on professional building contractors to remodel or build their homes, versus those who build themselves. According to the building contractors, a range of 40% to 75% of the population would contract a professional. Construction in sub-divisions is performed exclusively by professional builders, but empirically speaking, construction in the tenantries tends to be carried out by the residents and family members or friends, with the exception of the company-owned truckers that haul in the marl, concrete, or lumber (personal observation).

The price of concrete blocks depends on the thickness; blocks for building houses are typically 16" long, 8" wide, and available in 4", 6", or 8" thickness. According to the building contractors who were interviewed, they invariably build with the 8" blocks, which cost $2.00 a block, while the "do-it-yourselfers" tend to purchase the 6" blocks. Overall, the difference in cost for a timber house versus a concrete house is substantial; in 1986, a two- and three-bedroom timber house cost $11,700-$18,000 and $14,200-$24,000, respectively, while a 110m^2 concrete house--and only the house, not the lot--cost $66,000-$88,000 (Town & Country Development Planning Office 1988,p.46). The lot for that house ranged from $10,500-$13,500 (Town & Country Development Planning Office 1988, p.46).

The contractors interviewed all stated that concrete homes were built year-round, without concern for relative humidity and the problem of thorough drying. The professional contractors contend that the only problem with moisture and construction is in the older homes built of coral limestone, since the material is so porous and retains water. Construction of the average house, according to contractors, takes anywhere from four months to one year.

A number of building codes have been established to minimize damage to houses from tropical storms and termites. One such code that is apparently heeded to rather stringently is the code for laying a concrete foundation. First the foundation is dug, then filled with marl. Afterwards a vapor barrier (also called a "wind" barrier, or heavy polyethylene sheet) is laid over the marl, followed by a fabric reinforcement sheet, and finally the concrete is poured. Traditionally the soil was treated with an insecticide against termites before the marl fill and repeated before the vapor barrier was laid; however, recently the government banned the traditional chemical used against termites and the alternative is 10 times the old price, increasing treatment costs from 15 cents per square foot to more than $1.00 (Edghill Associates, Ltd., personal communication). Vapor barriers are not used on the concrete walls.

Construction in the poorer sectors is not so methodical. For those timber structures in which a concrete section is being added, a foundation such as that prescribed by contractors may or may not be constructed. For example, one family in the study, whose house was situated on a slope, simply constructed block stilts and then laid the floor over the blocks. If a household does choose to follow the foundation code, the benefit of termite-prevention spraying and the use of vapor barriers to prevent moisture are likely negated by the fact that the new section is joined to an older wood section, probably resting on moisture-retaining coral limestone rocks. Similarly, the foundation may be laid months or even a year before enough capital is available to complete the new section entirely (personal observation).

By law all building construction on the island must first be approved by the Town & Country Development Planning Office, regardless of who is doing the work. But one contractor noted a weakness in the system:

> Here are no stringent building laws. The people that do the Town Planning...are more concerned with how close the structure is to the main road, the fact that you're going to build a domestic in an area that is set up more for business or agriculture...There is no strict building code....The government won't say 'that's wrong', 'this is wrong'...They're very strict about your plans, and where it's located, and yet the quality of materials you use--there's no regulation. But if you build ya have to have certain codes, or standards. Especially if you have a contract...you have to have the specification in the contract, so you can't wiggle out of it...It's an ethic that builders and architects use, similar to the U.K. and the U.S..

Elaboration of the indoor environment

The average cost of carpeting is $54.00 per square meter, and most people buy carpet via high purchase[32]. Typically, a household that carpets a 12' x 24' room--almost without exception the living room--would pay approximately $60.00 per month over two years. Although carpeting is now common in Bajan homes, very few households own a vacuum cleaner (personal observation).

All of the attention to detail in the house is focused in the living room, where the family spends the majority of their time together and where guests are entertained. Furniture is very standardized in Barbados across the socioeconomic strata; it is almost without exception a mahogany frame with removable seat and back cushions, the cushions being made of crush velour fabric and filled with a two- to three-inch thick piece of foam. "More is better"--quantity is more reflective of what is affordable than the style, since there is only one style--and little attention

is given to the spatial distribution of furniture; in some homes sofas and easy chairs literally line the living room walls (personal observation).

The typical living room has an entertainment stand, varying in elaboration and expense, on which the television, VCR, and stereo sit. The reader should note that, in the asthma study, as was presented in Chapter Two, the number of households with at least one television was greater than the number of households with a refrigerator. Lace curtains are very popular and adorn every window, as well as each doorway in the house, even if a door is present. In keeping with the prevalent ornamental horticulture around the house, householders enjoy a number of indoor plants (personal observation).

In contrast to the front room, bedrooms are quite simple as a rule, usually just big enough for a double bed and perhaps a dresser. Closets are not common and many residents hang their clothes on nails driven along the bedroom walls, or store them in suitcases or cardboard boxes in the corners of bedrooms. Almost all bedrooms observed in the asthma study had a small rug next to the bed, though very few had carpeting (personal observation).

<u>Installation of indoor utilities</u>

Potter concludes that the low percentage of land ownership is significant in limiting the degree of housing upgrading among the masses in Barbados in regard to plumbing

and sewerage provisions (1986,1988,1989). Certainly an aspect of home improvement that has been admittedly slow in evolving--considering the economic development of Barbados compared to other West Indian countries--is the conversion from pit latrines and community water pipes to indoor plumbing. This factor is directly attributable to the fact that, if a tenant does not own the house spot, he/she cannot legally add permanent (concrete) structures to the home. In 1980, just over half (58.9%) of all Barbadian homes had piped water inside the home and less than half (47.8%) had indoor toilets (Potter 1986). Twenty-one percent of the households had a standpipe in their own yard and close to 10% had to rely on a public standpipe (1980/1981 Population Census 1985). In a 10-year period, the annual number of new water connections increased from 614 (1979) to 1,453 (1989) (Ministry of Housing and Lands 1990). Since Barbadians are charged for water based on the number of taps, when a family can finally afford indoor water, the household typically installs a kitchen sink and may continue to use an outdoor privy and shower until additional taps--and the construction of a bathroom--can be afforded.

Indoor plumbing and electricity was initiated on a large scale in the 1940s and 1950s, due to the availability of the technology and the large number of emigrants sending back remittances for home improvement. M. Hurley at the Valuation Department explains:

> In the 1950s, there was a lot of migration to England and Canada. A lot. The Barbadians there would send "expatriate funds" to their families, and people started to improve their houses. They would improve the house, and remove the shed. Or most common, they would build a wall bathroom-toilet, and just keep adding concrete. We use to have outdoor kitchens; they moved the kitchens indoors in the 1940s and 1950s. Running water was introduced in the 1950s...Then you could get an installment plan, where they put a tap in your house. You just paid for having that water into the house. That is something that people are angry about--now you have to pay for water based on the number of taps in the house, and rates have gone way up.

This step-by-step upgrading of the Bajan home is evident in the 1990s as well. When a Barbadian wants to improve his/her home, the first addition is an indoor kitchen. Once the kitchen is moved indoors, piped water for the kitchen sink is installed. The addition of an indoor toilet requires the construction of a new room, usually a small concrete room added to the rear of the house and a toilet is installed. If the family has the means, they will add a second concrete slot (at the same time or at a later date) next to the toilet slot, for a shower. It is not unusual for households to continue using an outdoor privy after the addition of an indoor toilet and shower, as a sort of "second" bathroom (personal observation).

Similarly to plumbing, the last 10 years have seen a dramatic increase in the number of electrical inspections for new dwellings; inspections increased from 1,213 in 1979 to 2,365 in 1989 (Ministry of Housing and Lands 1990). In 1985 the National Census Bureau reported 55,738 homes with

electricity, or 83% of all households (1980/1981 Population Census 1985). Electricity sales soared from 100 million kwhs in 1968 to 285 million kwhs in 1980; domestic sales accounted for 21% of that increase (Town & Country Development Planning Office 1988). Bottled gas is the predominant form of cooking fuel, although increasingly natural gas is being connected in a number of villages. In 1980, close to 30% of the households were relying on wood/charcoal, kerosene, or some form of cooking fuel other than gas or electricity (1980/1981 Population Census 1985).

The Role of the Family System

The impact of costs and tenure

The adaptable characteristic of the Bajan house form is due in part to the extended family. The economic advantages of the extended family are varied. Due to the economic constraints in Barbados, a young adult cannot easily afford to secure his/her own apartment or house, nor afford the items necessary for a new home (e.g., appliances). Typically, after completing compulsory education, a young person may choose to go on to college and/or university, or go immediately into the work force. By staying at home the young adult can save his/her money until enough capital is available for a home. Because of the extended family, if a young woman becomes pregnant, childcare provisions are available if she is working. A proportion of the young

adult's income is pooled into the family income, thus allowing the family to live in a higher quality home with many of the household amenities that they might not be able to afford individually.[33]

Marital (legal) and nonmarital (nonlegal) unions play a role in initiating a new household.[34] "Ian" and "Mary" recently had their first child. Mary has a 10-year-old son from a previous nonmarital union. She is 28 years old and Ian is 29 years. Just before the baby arrived, they moved into a new chattel that Ian built himself. They live in Cotton Vale, where Ian grew up, and Mary's family lives in the neighboring village. Ian explains:

> When does a young person decide to get they own house? Well, ya see different ways. Young people may live at home after school, while they work, and save they money. But if you are a Christian, if you a Christian follower, then I would say around 22 to 25 ya decide to get married. It's the thing to do. After ya get married, you live with the family or you rent...until you could afford to build a house. But if you not a Christian, then you in relationships for pleasure, see, no responsibility. They put off the responsibility, so they can move around and don't have to be at one place...

The fact is, however, that a legal marriage in Barbados is unrelated to religious affiliation (Dann 1984) and as was discussed in Chapter Two, the likelihood of engaging in legal marriage increases with age. Nevertheless, "Ian's" narration regarding a young couple's move to set up their home is applicable to common law unions as well.

Trends in household density

Household density has traditionally been used as an index for socioeconomic status. Lowenthal noted from the 1946 census that, despite the extreme population density, household density was lower there than the other British West Indies, at 1.55 persons per room (1957). He did find, however, that within Barbados, room density was inversely proportional to regional population density; the very rural parishes of St. John, St. Joseph, St. Lucy and St. Andrew, with densities of 1.92, 1.71, 1.69, and 1.86 persons per room, respectively, were considerably higher than a density of 1.36 in Bridgetown.

Using preliminary figures from the 1990 Population Census, a trend is observed in population density per household by parish (total number of persons per parish divided by the total number of households in that parish) (note: figures were not available to calculate density per room for 1990) (unpublished data). Table 3-10 illustrates the gradual but very steady decline in household density for each parish from 1970, 1980 and 1990. When a comparison is made to Lowenthal's report from 1946, it is apparent that significant changes over a 24- to 44-year period were only made in a few of the parishes and those were the very rural parishes in which a great deal of urban migration has occurred.

An important development, however, is not so much the shift in household density in general, but the increasing number of rooms in contemporary homes, which is probably reducing the overall household density, when calculated by total number of persons divided by the total number of rooms. Historically, the average Bajan home was a two-room structure; Lowenthal, relying on statistics from 1946, concluded that, in the most rural and distressed parishes along the windward coast, more than half of the households had a density of greater than two to a room, and the most common arrangement for the entire island was four persons living in a two-room house (1957). From the 1980 census, it is apparent that more than 78% of the population lives in a dwelling with four rooms or more (1980/1981 Population Census 1985, see Table 3-11), thus illustrating a significant change in household spatial distribution patterns and suggesting an increase in the number of bathrooms and bedrooms per household. Similarly, just over half of the households (56.6%) had four or more persons living in one dwelling (1980/1981 Population Census 1985), rather than the majority as Lowenthal reported.

Housing Trends and Health Implications

Moisture

Excessive moisture levels develop within the home in a number of different ways. Two well-known means of moisture build-up in homes of temperate climes are not factors in

Table 3-10. Number of persons per household by parish, for the years 1946, 1970, 1980, and 1990.

Parish	1946[a]	1970[b]	1980[b]	1990[b]
St. Michael	2	3.8	3.4	3.4
Christ Church	4	3.9	3.6	2.8
St. George	4	4.4	4.0	3.8
St. Philip	4	4.3	3.8	3.1
St. John	7	4.6	4.2	3.8
St. James	4	3.8	3.5	3.0
St. Thomas	4	4.3	3.9	3.7
St. Joseph	6	4.6	4.1	3.7
St. Andrew	5	4.6	4.2	3.9
St. Peter	4	4.2	3.8	3.3
St. Lucy	6	4.1	3.9	3.4

Source: [a]Lowenthal, D. 1957,p.473. (Note: figures denote "mode")
[b]1990 Population Census, unpublished data.

tropical, developing countries--those are winter moisturecondensation on windows and moisture that is deliberately added via humidifiers. Means of achieving high levels of moisture in the home that do apply to an environment such as Barbados are moisture build-up via normal living activities, household density, and ground moisture (absorbed through crawl space floors or foundation walls via wicking from the wet soil). This is, of course, in addition to the persistently high relative humidity that is part of the macroenvironment.

Hansen (1984) estimates that a family of four produces an average of seven to twelve liters of water per day by means of daily living activities such as clothes drying,bathing, and cleaning the floor (Table 3-12). Even bodily functions (e.g., exhaling) contribute ca. 0.18 liters of moisture per hour, per person, to the environment (Hansen 1984).

Table 3-11. Percent of households calculated for the number of persons by the number of rooms.

Number of Persons	Number of Rooms								Percent of households	Percent of Total Households
	1	2	3	4	5	6	7 & over	Not stated		
1	4.6	18.1	19.4	32.9	13.3	2.5	1.1	8.1	100.0	22.0
2	1.4	7.2	14.4	40.1	22.9	5.1	2.7	6.2	100.0	19.5
3	0.8	5.2	11.1	37.6	29.3	6.7	3.4	5.9	100.0	15.1
4	0.4	4.2	9.1	34.4	32.8	8.5	4.6	6.0	100.0	13.5
5	0.4	3.9	9.0	32.5	34.4	8.9	5.1	5.8	100.0	10.0
6	0.4	3.7	8.0	30.2	37.4	9.6	5.1	5.6	100.0	7.1
7	0.4	4.1	8.3	30.9	36.8	10.9	3.6	5.0	100.0	4.7
8	0.3	2.9	7.6	27.1	39.6	13.2	4.3	5.0	100.0	3.1
9	0.3	2.6	6.9	24.9	38.7	16.5	4.1	6.0	100.0	2.0
10	0.1	2.1	7.8	23.3	41.1	14.6	5.9	5.1	100.0	1.2
11	0	1.6	7.5	23.1	36.7	19.0	7.6	4.5	100.0	0.8
12	0	2.6	6.1	19.1	35.8	22.0	7.9	6.5	100.0	0.5
13+	0.4	2.3	3.5	19.2	38.0	21.8	9.3	5.5	100.0	0.6
Total	1.5	7.8	12.4	34.2	27.2	7.1	3.4	6.4	N/A	100.0

Source: 1980/1981 Population Census. 1985, p.238.

Table 3-12. Sources of moisture in the home. Figures are based on a family of four living in a one-story bungalow with a full basement and ground floor area of $111m^2$ (1200 square feet).

Sources of Moisture	Quantity in Liters
Clothes drying* (unvented)	11.97
Cooking*, gas (unvented)	2.16
Clothes washing* (unvented)	1.96
Floor mopping (7.4 m^2)	1.09
Cooking*, electric (unvented)	0.92
Dish washing*	0.45
Bathing, shower	0.23
Human contribution (per hr.)	0.18
Bathing, tub	0.05
House plants (per hr.)	0.02

*Figures for a family of four.
Source: Hansen, A.T. 1984,pp.231-1.

Although activities of daily living are significant sources of moisture in the home, the biggest culprit in moisture build-up is the structure itself. Exposed earth and rock under the house produces up to 45 liters of water per day when the soil is wet (Hansen 1984), and in temperate climates, crawl spaces are reportedly the single most important factor in moisture build-up in the house (Moffatt 1992). Admittedly, the build-up of moisture is reduced in the event that a polyethylene sheet is laid before pouring the concrete foundation. But as described, not everyone in Barbados utilizes a moisture barrier. A significant amount of moisture is added to concrete and plaster during construction, and during the first year much of this moisture may be released inside the home (Hansen 1984).

Even when polyethylene moisture barriers are used on the foundation slab, there is remarkable moisture that is wicked via concrete foundation walls (Moffatt 1992). Of the four major moisture transport mechanisms in buildings, including (1) liquid flow as a result of gravity and air pressure difference, (2) capillary suction, (3) air movement and (4) vapor diffusion, the first two, liquid flow and capillary suction, are most important moisture mechanisms whereby rain and ground water are the primary sources (Christian et al. 1992).

Another moisture-related problem that applies to almost all Barbadian homes is the minimal use of gutters in housing (personal observation). Considering the large amounts of rainfall in a short period of time and persistent rainfall during the rainy season, the tradition of allowing water to drip off the edge of the roof and onto the ground surrounding the house no doubt contributes tremendously to moisture build-up, affecting all types of foundations (e.g., soil, coral rock, and even concrete). Regarding water run-off from houses, J.C. May found the following:

> Splash from overflowing gutters is the most common cause for moisture and pest decay of foundation sills at masonry landings and at wood decks abutting the foundation of a house. Improper dispersal of roof water at downspouts is the main cause of wet basements and subsequent mildew. (1992,p.49).

Certainly "overflowing gutters" are less of a problem than the lack of gutters altogether, as in Barbados.

Concrete structures are erected in Barbados regardless of the season, rainy or dry. Christian et al. note that, although building assemblies may start out wet due to construction under wet conditions, as long as the rate of moisture entry does not exceed the rate of moisture removal (e.g., a drying period), then "acceptable performance" can still be achieved in that the materials do not deteriorate due to persistently adverse (wet) conditions (1992). While the building contractors interviewed argued that moisture build-up in new concrete structures was not a problem, even when constructed in the rainy season, the combination of constant rain and ground water flow plus minimal air movement during the months of August to November cannot be overlooked as real impediments to the drying process.

The materials used for new homes--primarily concrete--are probably less a factor in contributing to moisture build-up in the home than is the method of construction. Quite simply, availability of credit for home building is limited, and the system works against the lower income groups, who are forced to build in piece-meal. Such building practices often negate the methodical use of moisture barriers in concrete foundations and the treatment against termites (personal observation).

Certain moisture-related sources <u>inside</u> the home are also a factor in indoor humidity levels. Again, quoting the work of J.C. May, a discovery made in a home inspection in

Massachusetts certainly applies to any locale, including Barbados:

> An asthmatic was interested in eliminating sources of asthma triggers in her house. We uncovered one foul source after another, but the refrigerator drip pan was the most egregious. I noted in my own kitchen that I started coughing every time the refrigerator compressor started. Curious, I removed the grille (that always needs a few good kicks of encouragement to replace) and pulled out the drip pan. In the middle was what once must have been an onion, now about twice its size and covered with mold. Every time the compressor turned on, air from the blower sent spores from the blob into the room. When was the last time you cleaned out the drip pan of your refrigerator? (1992, p.55).

Leaky faucets under sinks (where many Barbadians store empty drink bottles and cooking utensils) no doubt contribute to moisture build-up in the kitchen area. Traditional "moisture problem" sites inside the home include mildew build-up under furniture, inside closets, and on wall surfaces (Sherman 1992). Leaky potted plants and improper carpet cleaning have been implicated in abundant mold growth (Brunekreef et al. 1989).

The deleterious effect of moisture in housing on health has received particular attention in regard to respiratory disease. A study in London revealed that children sleeping in bedrooms with relative humidities greater than 75% for a full week exhibited higher prevalence rates of respiratory illness than children sleeping in rooms of lesser humidities (Melia et al. 1982). In a similar study, Murray and Zuk (1979) reported a significant increase in hypersensitivity

to house dust mites for children in living in damp homes as compared to children living in dry homes. Platt et al. (1989) found that both adults and children living in damp homes had a greater prevalence of respiratory symptoms than adults and children living in dry homes.

The relationship between a damp indoor environment and respiratory disease is primarily due to the presence of molds (Burr et al. 1985; Brunekreef et al. 1989; Platt et al. 1989; Dales et al. 1991), fungi (May et al. 1986) and house dust mites (Bronswijk, J. 1973; Murray & Zuk 1979). In several studies, respiratory disease as a result of the presence of these various agents was not dependent on already-existing disease states such as asthma (Brunekreef et al. 1989; Dales et al. 1991). The severity of respiratory disease associated with molds has been found to be dose-dependent (Platt et al. 1989).

It is important to note that in the majority of the studies on dampness and respiratory disease, the research was conducted in temperate regions, primarily focusing on a dampness range of 40% to 60% (Spengler et al. 1992). Furthermore, in most of the studies described above, independent variables such as smoking, socioeconomic status, age and sex were considered, but in none of the studies did the researchers consider the role of the house <u>structure</u>.

Molds exhibit a critical relative humidity level of just under 80% to greater than 90% (Gravesen 1979). While

house dust mites depend on human skin scales for nourishment and exhibit a preferred temperature range of 17-32° C, the most critical constraining factor for their survival is a relative humidity level of above 55% (Korsgaard & Iversen 1991) (see Chapter Five for a thorough discussion on house dust mites). Certainly the tropical climate of Barbados provides an ideal environment for both of these disease-causing agents.

Ventilation

Fraser and Hughes (1986) identified a number of characteristics in the traditional chattel and great houses that allowed for optimal ventilation, including the wide verandas, demerara and jalousied windows, high gables and tray ceilings. But, as explained, many of these features are disappearing in the construction of new Barbadian homes. The new "fad" is the closed-board ceiling, or a finished ceiling. A closed ceiling reduces air flow within the house, lowers the ceiling, conceals the rafters and the underside of the roof and increases the temperature inside the house. Also, whereas in the past, consideration was given to prevailing winds when situating a structure and constructing the windows, one building contractor lamented that "now people want to face the sunset", or select window openings for other aesthetic purposes (Nicholls & Edghill Construction, Ltd.,[35] personal communication). Furthermore, as tenantries--especially those in the urban

sector--become more and more crowded, houses are erected and additions made in whatever space is available; space typically precludes strategic positioning in terms of air flow.

The characteristic of adding concrete structures behind the main unit of the house has been discussed, and the fact that these concrete structures are used to house indoor toilets and showers was presented. For the purpose of privacy, windows in these small rooms are typically placed quite high and, being relative to the size of the room, are small. Because the concrete structure is added onto the main unit, a window opening is usually only on 1 wall. These 3 features of the "added-on toilet/shower" should, theoretically, result in creating a space of very limited airflow.

Air conditioning is rarely used in Barbados, particularly in housing (personal observation). When asked, most Barbadians, including building contractors, will contend that it is not necessary, that the air temperature cools down significantly at night and electric fans are sufficient for circulating air in the home. When fans are used, they are placed where residents spend most of their time, either the living room or in the bedrooms, but not in small space areas such as the bathroom. Ceiling fans are a luxury and are not commonly found in the average Barbadian home (personal observation).

Similarly to moisture in the home, a number of studies have implicated poor indoor ventilation with respiratory disease (tuberculosis, Riley et al. 1959; Legionnaires' disease, Fraser et al. 1977). Admittedly, most of these studies have focused on buildings in temperate climes where decreased ventilation has been a deliberate action so as to conserve energy (e.g., heating, air-conditioning), whereas in a case such as Barbados, decrease ventilatory practices have been quite accidental.

Relative humidity in the dwelling is not due entirely to a change in structure--it is largely dependent on reduced ventilation. As Arundel et al. noted, in a discussion of the indirect health effects of the construction of sealed, energy efficient buildings, a compromise has been made in that "...the high fresh air ventilation rates found in older leaky buildings may dilute the concentration of pathogens, allergens and noxious chemicals in the indoor air and thus offset some of the health problems associated with relative humidity" (1986, p.359). Certainly, a similar picture emerges from the Barbados scene.

Summary

In summary, land distribution patterns were established early in Barbados, dictated by the planter elite and, more importantly, sugar monoculture. Early land distribution patterns played a major role in stratifying the population,

by creating a majority landless proletariat, that persisted well into the twentieth century.

National steps toward reform of land distribution have put into place policies that allow for the purchase of land by all Barbadians, although the transition has been sluggish, particularly in the densely urban sector. An outgrowth of reforms and overpopulation in the urban sector has been the birth of suburbs.

Although the use of concrete in construction of the domestic dwelling is preferable for a number of reasons (e.g., weather-proof, termite-proof, less maintenance), the author contends that the predominant influence in the use of construction has been the social stigma attached to a concrete home--concrete in the house is synonymous with land ownership. Therefore, the construction of concrete houses and the amenities associated with them (e.g., indoor showers, toilets, finished ceilings) are the aspiration of Barbadians as a whole. As demonstrated, these factors associated with the modern home are contributory to increased indoor relative humidity and decreased indoor ventilation--elements associated with the proliferation of house dust mites and possibly a host of other household pests.

Notes

1. The civil war in England contributed as many as 8,000 laborers between 1645 and 1650 (Beckles 1981), and by 1655 at least 12,000 prisoners of war had been sent (Chandler 1986). Cromwell's capture of the town of Drogheda in 1649 resulted in the shipment of a large number of Irish soldiers to Barbados, and in 1651, 800 Scot prisoners from the Battle of Worcester were sent (Roach 1984). Between 1654 and 1675, 2,000 servants came to Barbados from Bristol (Beckles 1980). Sometimes children were confiscated from orphanages, although those under the age of eight did not usually survive the voyage (Roach 1984).

2. Certainly at least as significant a factor in the preference for white servants was the low cost of servants compared to African slaves in the early sugar years. Middling and small planters--70% of all planters--found white servants to be cheaper overall than African slaves, because of the cost of buying, training, and disciplining slaves, and the high mortality of the Africans (Beckles 1981). In 1652 there were approximately 13,000 indentured servants and freemen employed on sugar plantations, nearly balanced with about 15,000 African slaves (Beckles 1981).

3. By the end of the 1650s, the price for indentured servants was increasing dramatically, as was their demand, in contrast to the beginning of the fall in slave prices. For example, in 1637, servants sold for seven pounds, but by the mid-1650s, a servant cost as much as 14 pounds; this was in contrast to a decrease in slave prices from 40.88 pounds in 1638 to 20.98 pounds in 1645 (Beckles 1990). Indentured servants were becoming more expensive in regard to transport, food, and wages, and the supply was inadequate for a sugar economy. During the 1660s, increasing punishment in England for the kidnapping of persons for servitude deterred would-be smugglers and diminished supply (Watson 1970; Beckles 1990).

4. The white indentured servants of the seventeenth century earned a number of derisive nicknames, to which they are referred even in modern Barbados. These nicknames, however, serve to demonstrate the class consciousness of the white plantocracy and the black population (enslaved and freed), both of whom despised the indentured servants. They were most commonly referred to as "Red Legs," a term which supposedly depicts the newly-arrived Scots who, wearing their kilts, developed sunburns on their legs after working

in the hot tropical sun (Watson 1970). Watson (1970) contends that, although the supposed etiology of this nickname denotes a Scottish origin for the Redlegs, family names among contemporary poor whites suggest a largely English origin (e.g., "Cheeseman," "Gooding," "Goddard," "Kinch"). "Poor Bakros" is another derogatory name, created either from the fact that white servants were forced to sit in the "back rows" during Church service, or as a derivation of an "African dialect word," "Bakra," meaning "white man" (Roach 1984).

5. As the plantation slaves increasingly acquired technical skills for which working-class whites were once hired, and as freed blacks moved into various trades, the poor whites were further marginalized into utter poverty, and left Barbados with a higher number of unemployed whites than in any of the other colonies (Handler 1974).

6. Contemporary "Redlegs" are distinguished from other poor whites on the island by virtue of the fact that their poverty extends back to more than a few generations; according to Watson,

> "...they have been poor since their arrival in the island some three hundred years ago and have been trapped in that poverty, consigned to the lowest rung of the social ladder in an island where possession of a white skin almost automatically puts one in the upper or upper middle class. They are a strange breed of people and are regarded as such--blue eyed hewers and toilers in a land where manual labour is regarded distastefully by white Creoles and all others who aspire to high social status... (1970, p.2).

7. Compared to the African slave system of the older Spanish colonies, slavery in the English and French colonies was particularly cruel. Williams notes the "appalling mortality" evident in Barbadian statistics; he explains that, after eight years of slave importations, 35,397 slaves had come into Barbados, while 31,897 disappeared (1970). It appears that after 1760, mortality among Barbadian slaves declined and the population was reproducing itself. According to Hoyos (1978), it was not until the abolition of the slave trade in 1807 that planters turned their attention to increasing the life-expectancy of the slaves (e.g., improved prenatal and antenatal care).

8. Research on the Dutch slave trade between 1640-1670, and trade by the Royal African Company between 1673-1700, suggests that most Africans transported to Barbados during the seventeenth century were from the following peoples:

the Adangme, Ibo, Ashanti, Dahomey, Ga, Edo, Ewe, Fanti, and Yoruba (Beckles 1990).

9. This is not to infer a total loss of African culture in Barbadian society. Legal suppression of such African magico-religious practices as Obeah merely forced the belief system underground, but did not eradicate it. Bush teas were commonly used, and reliance on slave midwives and their medical knowledge, along with the borrowing of medicinal practices by the poor whites and subsequent diffusion upwards through the classes, contributed to the Africanization of Barbadian culture. Additional manifestations of Africanisms include superstitions, folk tales, and food preparation (Watson 1979).

10. J.C. Hudson, Chief Executive, Carib Agro-Industries Ltd., Edghill, St. Thomas, Barbados.

11. It should be noted, however, that acquiring a loan for land and a house has and continues to be a particularly difficult process in Barbados, in that the mortgagor is responsible for all charges and costs, including legal fees involved in the application process, regardless of if he/she receives the loan or not (Nurse 1983). Loan agencies sometimes demand an insurance policy equivalent to the loan value, or the difference between the total equity value price and the loan (Nurse 1983). Consequently, building a home on a sub-division has evolved into a two-staged process, in which the lot is financed first, typically over a five-year period, so that a mortgage can be secured for the construction of a house (Nurse 1983).

12. The 1970 Census estimated a 9.4% unemployment level, which rose significantly to 15-17% in 1976-1977 (Nurse 1983). The figure remained unchanged at 16.9% in 1983, rose sharply to 22.9% in 1987, and dropped to 18.6% in 1987 (PAHO 1990), although currently, the unofficial unemployment figure is close to 20% (Hudson, personal communication).

13. Schofield (1991) identified five factors associated with the decline in labor, concluded from interviews with church rectors, and included: The link with slavery; political factors, such as Barrow's speech; less power to estates, by means of legislated tenant rights and financial pressure to sell estates to the emerging black middle class; free education to all, thus raising employment expectations and opportunity above manual labor; and "other opportunities," such as improved transportation in and out of the metropolitan region, and increasing job opportunities in the non-agricultural sector.

14. "Bajan" is a colloquial reference to anyone who is Barbadian-born or anything that is of Barbados, e.g., "Bajan cuisine," "Bajan ways," and particularly the "Bajan dialect." "Bajan" denotes a creolization process of the African and English culture, and is uniquely Barbadian.

15. It is difficult to determine exactly how many Barbadians are employed by tourism, as many benefit indirectly from the industry, and an unknown proportion classified as "underemployed" probably contribute as well (e.g., snack food vendors, beach peddlers). Noel Drakes of the Ministry of Tourism and Sports reports that tourism employs roughly 20,000 Barbadians--10,000 directly and 10,000 indirectly (personal communication). If the number of visitors to the island is an indication of its status, Barbadian tourism is in good standing, as the number of visitors to the island rose from 471,357 in 1985 to 794,903 in 1990 (Drakes, personal communication).

16. "Leeward" literally refers to the side to which the wind is blowing. In the eastern Caribbean, or Windward Islands, of which Barbados is a part, the leeward side of the island faces the Caribbean sea, while the windward side faces the Atlantic. As the tropical breezes blow from the Atlantic into the Caribbean Basin, or, from the northeast, the leeward coast is considerably calmer than the windward, as it is protected by the land mass, or island. Consequently, primate cities and harbors were established on the leeward coast, where ships could enter safely, and damage due to hurricanes could be expectedly less than that on the windward coast. Barbados has long endured scrutiny regarding its legitimate placement in the Caribbean; some argue that, geographically, Barbados sits outside of the Caribbean Basin, and in the Atlantic. For example, Vincentians and Grenadians alike refer to their windward coast as the Atlantic, and Barbados lies approximately 100 miles west of those islands. Cognitively, however, Bajans have created a mental map in which the Caribbean sea lies on the leeward coast, and the Atlantic on the windward.

17. There is an apparent relationship between the decline of the sugar industry and the increasing sub-division of previously agricultural land into residential lots, although the cause-and-effect is debatable. J.C. Hudson argues that the initial effect of the Tenantries Act was positive for the sugar industry, as home and land ownership served to reduce the stigma associated with plantation work, and a field laborer was no longer synonymous with "landless proletariat" (personal communication). Nurse (1983) contends that sub-division is a result of, rather than the cause of, the declining industry. In analyzing the period

between 1965 to 1977, he observed a 25% decline of cane land (13,200 acres), and of that, only 4,000 acres of active farmland were converted to residential lots (Nurse 1983). The number of rab (idle land) acres converted to residential lots jumped from 6,000 to 17,000 acres, suggesting that, had that idle rab land not been transformed into residential land, it would remain in disuse (Nurse 1983).

18. M. Hurley, Valuation Department, Department of Taxation, Bridgetown, Barbados.

19. M. Broome, Chief Licensing Officer, Ministry of Transport & Works (MTW), St. Michael, Barbados. Mr. Broome provided unpublished information on the number of motor vehicles in Barbados as of February, 1991.

20. P.Y. Barrow, Permanent Secretary, Ministry of Housing and Lands, Marine House, Hastings, Christ Church, Barbados. Ms. Barrow provided unpublished data and statistics based on the 1980 Census regarding housing in Barbados.

21. Prior to 1968, the Barbados government practiced a taxation method based on the English system, in which only the land was taxed ("site value"), rather than the total <u>value</u> of the land plus the structure situated on the land ("improved value"). The theory behind this original taxation method was that, if the land was going to be taxed regardless of the development on that site, then development by the owner might actually be stimulated. The law was changed because it was felt that, if an owner had the capital to maximize his/her lot, then he/she should be taxed according to the wealth of the lot. This philosophy evolved into the current taxation system, in which every three years parcel values are assessed by the Commissioner of Land Tax, and the resident is charged a "site value" tax (0.6% up to $100,000 BDS and 1% thereafter) and an "improved value" (0.35% up to $300,000 BDS and 0.95% thereafter). Foreign-owned land is charged a 3% "site value" and a 2% "improved value" (Hurley, Valuation Department, personal communication).

22. The "demerara window" is derived from Guyana, and sometimes referred to as a "cooler window" (Fraser 1990). It is a full-sized window with a single shutter, which hinges at the top and "pushes out." Once opened, it is supported by a long stick or rod that is stuck against the sill to keep it in place. Bajans refer to this window-type as a "push-out" window, and admit that it allows for maximum ventilation. The term "cooler window" refers to the tradition of keeping a large clay water jug, or "monkey,"

filled with water, on the window ledge, a device which, situated in the path of a breeze, would deep the water cool.

23. "Georgian" refers to an architectural style prevalent during the reign of the Georges of England, during the eighteenth and nineteenth centuries. In the West Indies, the English style of architecture had a greater influence on design than did any other European country, regardless of the European sovereignty for a particular island, with some exception in those colonies under Spanish rule. The style itself was actually popularized by four architects, including Christopher Wren of Virginia, who combined the interpretations by Inigo Jones (1573-1652) of the Late Renaissance architect, Andrea Palladio (1508-1580), as well as the increasingly popular Dutch Palladianism style, to develop a country house model that would be constructed throughout England and her colonies. The West Indians, however, did not follow the model as closely as the North American colonists, for a variety of reasons, including societal and labor influences, climate and resources, and subsequently evolved what is termed as "Caribbean Georgian" (see Gosner 1982 for a full description).

24. A long-standing tradition in Barbados is large-scale home improvement during the Christmas holiday season. This is the time when most workers receive a holiday bonus, and use the extra cash to up-grade the home. A local department store reported that Christmas time was their busiest time, not so much in gifts, but in the sales of appliances and furniture, when "people want something new. They want to show off their house...". According to another informant, holiday home improvement begins around the first of December, and continues "right up to Christmas Eve, sometimes Christmas Day...'cause ya never know if someone might be stopping by for the holiday, and they want their house to look just so."

25. R. Hughes, historian and researcher. Mr. Hughes has conducted research at the University of the West Indies (Cave Hill campus) regarding Sugar Plantation Ownership and Development in Barbados.

26. In 1663 a group of Barbadian planters received a grant from the King of England to establish a settlement in what is now Charleston, South Carolina. The venture was primarily in response to the early scarcity and escalating price of land in Barbados. Although the first colony of 1664-1667 failed, a permanent settlement was established in 1670. A number of Barbadian contributions left a lasting influence on Charleston, including place names, cane economy, and most notably, architecture. Of particular interest is the 'single house' of Charleston, a long,

narrow, single-room wide house, with a single gable roof, and a long veranda on one side of the exterior. There is contention the African-derived Gullah dialect of the Carolina coast and islands resembles Bajan dialect, although a definitive relationship has not been established, and credence must be given to the fact that North American and West Indian slaves all shared a common West African ancestry. (See Alleyne & Fraser 1988 and Fraser et al. 1990).

27. G. Dann, Senior Lecturer in Sociology, University of the West Indies (Cave Hill), Barbados.

28. W. J. Babb, National Housing Corporation, Country Road, St. Michael, Ministry of Housing and Lands, Barbados.

29. D. Daisley, General Manager, National Housing Corporation, Country Road, St. Michael, Barbados.

30. Edghill Associates, Ltd., General Contractors, Wildey, St. Michael, Barbados.

31. Oran Ltd., Harbour Industrial Park, Bridgetown, Barbados, W.I.

32. Courts Department Store, Oistins, Christ Church, Barbados.

33. Economic constraints, national health care, and greater access to birth control have no doubt had an affect on the fertility rate in Barbados. In the asthma study, women were asked what they believed to be the "ideal" number of children, and the mean number reported was 3.97 (note the difference in the median of 2, and mode of 2). The average number of children that the informants actually had was 2.9 (median=3, mode=2), demonstrating relative consistency between the median and mode; but oddly, the actual is less than the "ideal" mean number. This difference was statistically significant (r=0.17, p=0.03). When asked if they believed women were having fewer children "these days", 105 (61.0%) answered in the affirmative, and when asked why (open-ended question), the most common response was that children are "too expensive nowadays" (N=50, 29.1%) followed by the availability of birth control (N=27, 15.7%) (note: 63, or 36.6%, would not respond). The official fertility rate in Barbados has actually decreased significantly, from 4.7 in 1950-1955, to 2.0 in 1985-1990 (PAHO 1990); this figure is, for reasons poorly understood, lower than the fertility rate of the sample.

34. In Barbados, as elsewhere in the Caribbean, union status is typically divided into the following: 1) legally married; 2) common law union, recognized as the same as marriage, but the union has not been formalized according to East Indian custom, or by law; 3) visiting, in which the couple does not share a single dwelling; and 4) single.

35. Nicholls & Edghill Construction, Ltd., Frere Pilgrim, Christ Church, Barbados, W.I.

CHAPTER 4
THE ASTHMA STUDY: AN ANALYSIS OF CONTEMPORARY LAND TENURE PATTERNS, HOUSING, AND ASPIRATIONS

In the previous chapter, a detailed historical review of the evolution of land tenure and house forms in Barbados was presented, as well as the effects of the political, economic, and social forces that shaped contemporary housing. In the proceeding paragraphs, the suggestions presented in Chapter Three will be analyzed in terms of a contemporary, sample population. A review of contemporary trends in land tenure and distribution, combined with verbalized aspirations for the ideal home, will elucidate the direction of Bajan housing from the world view of a sample of Barbadians. For the purpose of this study, it will allow for the assessment and selection of housing variables that are representative of the modernization process and the identification of associations between sociodemographic and architectural variables that may or may not affect asthmatics, by providing ideal habitats for allergenic household pests.

Spatial Distribution of Land and Sociodemographics

Although a great deal of attention has been focused on the development of suburbia in Barbados, the island is,

nevertheless, primarily dichotomized into urban and rural districts (Figure 3-2, Chapter Three). Furthermore, there is little difference between rural tenantries and rural heights and terraces regarding the "clustering" effect, other than the fact that homes in heights and terraces are situated on relatively larger lots. The overt difference between the two residential areas is the building material and quality of the homes--new suburban homes are built almost entirely of concrete and homes in tenantries vary, but have traditionally been of wood and are increasingly built of mixed materials.

Households in the asthma study were delineated as either "urban" or "rural," although a breakdown by "type" of residential region was considered when appropriate (e.g., rural tenantry, suburban height/terrace). This decision was based in part on the focus of house-type as an important independent variable in the study and the fact that "tenantry" status does not exclude the possibility of living in a "modern," concrete house.

Although 141 informants (79.7%) stated that they owned their homes either outright, through mortgage, or by government grant, only 92 (52.0%) owned the land on which the house was situated. Land ownership was positively correlated to rural residency (X^2=10.83; 1 df, p=0.001), to demographic site (f=21.55; df=1, 175; p<0.001), and to parish (f=9.25; df=1, 175; p=0.003). Thirty-nine (42.4%) of

the urban residents owned their house-spot compared to 53 (57.6%) of the rural residents. Table 4-1 illustrates the breakdown of land ownership by demographic region; the highest percentage of landowners was for residents in the peri-urban district (81.8%), suburban heights and terraces (of the five suburban residents in the study, four owned their own land), and the rural tenantry residents (68.0%). Only 25% of residents in the most densely populated regions owned their land. These data correspond with studies heretofore outlined.

Table 4-1. Land ownership patterns according to demographic region (N=177).

Region	Frequency of land ownership	Percent of land ownership
Densely populated (within 2 miles of Bridgetown)	11	25.0
Semi-urban	16	41.0
Peri-urban (in urban district, visible agriculture)	9	81.8
Suburban height/terrace	4	80.0
Rural tenantry	51	68.0
Government housing, rural	0	0
Mixed rural (tenantries & suburban heights/terraces)	1	50.0
TOTAL	92	N/A

Table 4-2 shows the distribution of landowners by parish, illustrating that the parishes most important in tourism, manufacturing and government--St. Peter, St. James, and St. Michael--have the least number of landowners, and the parishes which are fast becoming the "suburban"

parishes, such as Christ Church, St. Philip, St. Thomas, and to a lesser degree, St. George, are relatively high in land ownership. Keeping with tradition, the very rural parishes of St. John, St. Joseph, St. Lucy, and especially St. Andrew also showed a high degree of land ownership.

Land ownership was not correlated to sex, age, marital status, educational level, or occupational status, although it was very strongly correlated to wealth as measured by "amenities" ($t=4.12$; $df=166.1$, unequal variance, $p<0.001$). Persons living on larger plots were more likely to own the land ($f=20.43$; $df=1, 174$; $p<0.001$), and the fewer the number of dwellings on a single plot, the more likely the household was to own the land ($t=4.77$; $df=100.4$, unequal variance, $p<0.001$).

Ownership was positively correlated to length of time on the plot of land ($t=3.02$; $df=165.6$, unequal variance, $p=0.003$), possibly indicating a number of lots belonging to family and having been passed on to heirs. Of the 107 informants who stated that the home was built by their household or family, 59 (55%) said that the land belonged to or had been purchased by their parents or grandparents. Regarding inheritance, 67 of the landowners (62.6%) stated that all children and/or family members would inherit the plot; four (3.7%) specified one individual to inherit the land, and 36 (33.6%) were not sure who would inherit the land, or could not answer the question.

Only 30 informants (or 17%) lived on a lot larger than one quarter acre, while 142 (80.7%) lived on lots of one quarter acre or smaller (four informants were not sure of the size). Seventy-six of those homes (42.9%) shared the lot with at least one other dwelling, indicating a fair degree of external crowding. The distance from the nearest neighbor (in yards) was related to owning the land (t=2.28; df=101.7, unequal variance, p=0.02). Table 4-3 shows that the same regions in which there was a high degree of land ownership are also the regions in which there is the greatest distance between neighbors--the peri-urban suburban heights and terraces and rural tenantries. However, distance from the nearest neighbor was not related to parish or urban/rural residency and not to socioeconomic status, thus reiterating the crowded nature of Barbadian housing in general.

Table 4-2. Frequency and percentage of households owning their residential lot, by parish.

	Landowners			Non-Landowners		
Parish	Frequency by parish	Percent of ownership for individual parish	Percent of ownership for all parishes	Frequency by parish	Percent of ownership for individual parish	Percent of ownership for all parishes
Christ Church	6	54.5	3.4	5	45.5	2.8
St. Philip	9	75.0	5.1	3	25.0	1.7
St. John	15	79.0	8.5	4	21.0	2.3
St. George	4	50.0	2.3	4	50.0	2.3
St. Joseph	2	66.7	1.1	1	33.3	0.6
St. Andrew	4	100.0	2.3	0	0	0
St. Lucy	7	63.6	4.0	4	36.4	2.3
St. Peter	8	40.0	4.5	12	60.0	6.7
St. James	7	38.9	4.0	11	61.1	6.2
St. Michael	24	38.1	13.6	39	61.9	22.0
St. Thomas	6	75.0	3.4	2	25.0	1.1
Total	92	N/A	52.0	85	N/A	48.0

Table 4-3. Distance from the nearest neighbor (in yards) according to demographic region (N=177).

Region	Number of Informants	Mean distance	Median distance
Densely populated (within 2 miles of Bridgetown)	44	6.3	5
Semi-urban	39	9.1	5
Peri-urban (in urban district, visible agriculture)	11	20.5	15
Suburban height/terrace	5	21.8	15
Rural tenantry	75	18.2	5
Government housing, rural	1	0	0
Mixed rural (tenantries & suburban heights/terraces)	2	11	11
TOTAL	177	13.3	5

The "Ideal" Place of Residency

An important factor in developmental trends in housing is the degree of satisfaction with the location of one's home. In his "Quality of Life" study, Dann (1984) found that, contrary to other sociological studies, "district," or residential region, placed low on the list of priorities for Barbadians. Yet Dann noted that he could not be sure if this result was "because of satisfaction" and a "taken-for-granted attitude", or because of another unknown phenomenon (1984, p.81). Potter (1983a) observed that, when informants were asked which parish they would prefer to live, the majority cited the parish in which they currently resided. His sample, however, did not include members from all 11 parishes; rather, respondents were from Bridgetown, Oistins, Six Cross Roads, Speightstown, and Belleplaine. He did note that the most preferred areas overall were the most affluent parishes of Christ Church, St. James, St. Philip, and St. Thomas, respectively, and that the more rural and "traditional" parishes were generally less preferred (Potter 1983a).

Respondents in the asthma study were asked the following: If they could live anywhere, where would they prefer to live? Table 4-4 illustrates the results from this question, referred to as the "ideal place of residence," and depicts an overwhelming preference for one's home parish (note: Only 166 informants responded to the question). The

parish with the highest degree of preference for one's own parish was St. Philip; 100% of the informants from St. Philip stated that it was the "ideal" place to live. Reasons for high satisfaction with St. Philip are probably related to the fact that its residents enjoy some of the most sought after beaches, commuting is relatively easy in and out of Bridgetown, and the parish is technically part of the urban belt, without the congestion of the urban center. Interestingly, residents who were least satisfied with their home parish were those from St. James (35.3%) and St. George (40%). This is perhaps because residents of greater affluence have more pronounced material aspirations (Dann 1984) and St. James and St. George are typically suburban parishes. Informants living in Christ Church, St. Peter, and St. Thomas were highly satisfied, as were the rural residents of St. Andrew and St. John.

Residents living in St. James and St. Michael were most diverse in their responses; many preferred parishes surrounding their home parish. This reflects the shift of residency from the highly urban districts to the suburban regions (of these two parishes, only two informants preferred to live in a traditionally rural parish; the remainder of respondents chose the semi-urban parishes). Two residents in St. Michael stated that they would like to live "someplace in the country." One person in St. George, the centermost parish, stated that she wished she lived by

the sea, and one informant in St. Michael wanted to live "someplace airy."

When the parishes are ranked in order of overall preference (as opposed to preference according to residency), discretion is noted between what the total population prefers and where the total population actually resides (Table 4-5). For example, St. Michael ranked as the most preferred parish to live (19.9%), but nearly twice as many informants actually lived in St. Michael (36.8%) than the number who cited the parish as the "ideal place to live," indicating that a number of St. Michael residents would prefer to live elsewhere. Conversely, nearly twice as many people would prefer to live in St. Philip and Christ Church than actually do and, similarly, there was disparity for the suburban parishes of St. George and St. Thomas. In short, the asthma study results concur with Potter's study, which indicates an overall preference for what is perceived as "affluent suburbia."

Table 4-4. Analysis of residential preference by parish among households. The proportion of informants in each parish citing the "most preferred parish" for residence (N=166).

"Ideal" Parish	Christ Church	St. Philip	St. John	St. George	St. Joseph	St. Andrew	St. Lucy	St. Peter	St. James	St. Michael	St. Thomas
Home Parish[a]	70.0	100.0	72.2	40.0	50.0	75.0	40.0	68.4	35.3	50.8	75.0
Christ Ch.	N/A	0	5.6	40.0	0	0	20.0	5.3	5.9	13.1	12.5
St. Philip	0	N/A	5.6	0	0	0	10.0	10.5	11.7	13.1	0
St. John	0	0	N/A	0	0	0	0	0	0	0	0
St. George	20.0	0	0	N/A	0	0	0	0	5.9	4.9	0
St. Joseph	0	0	5.6	0	N/A	25.0	0	0	0	3.3	0
St. Andrew	0	0	0	0	0	N/A	0	0	0	0	0
St. Lucy	0	0	0	0	0	0	N/A	0	0	0	0
St. Peter	10.0	0	0	0	0	0	10.0	N/A	11.8	0	0
St. James	0	0	5.6	0	50.0	0	20.0	15.8	N/A	3.3	0
St. Michael	0	0	0	0	0	0	0	0	17.7	N/A	0
St. Thomas	0	0	0	0	0	0	0	0	11.7	4.9	N/A
Other[b]	0	0	5.4	20.0	0	0	0	0	0	6.6	12.5

[a]Percent naming the parish in which they resided as the most preferred parish; "N/A" is entered in the row representing that parish.
[b]Responses other than a specific parish, including "a place in the country," "seaside," "someplace airy," and "anywhere."

Table 4-5. Overall rank of parishes as "the ideal place to live" according to the total informant population (N=166).

Parish	No. of informants preferring parish	Percent of informants preferring parish	Percent of informants living in parish
St. Michael	33	19.9	36.8
St. Philip	24	14.5	7.2
Christ Church	22	13.3	6.0
St. Peter	17	10.2	11.5
St. James	15	9.0	10.2
St. John	13	7.8	10.8
St. George	8	4.8	3.1
St. Joseph	4	2.4	1.2
St. Lucy	4	2.4	6.0
St. Andrew	3	1.8	2.4
St. Thomas	10	6.0	4.8
Other	13	7.9	0
Total	166	100	100

Implications for Trends in Housing

The asthma study statistics support what has already been discussed by governmental planners and developers, geographers, and sociologists in Barbados: There is continued growth and settlement in the urban belt, especially the semi-urban sector, with disproportionate land ownership in regard to urban/rural residency and socioeconomic status. Increasingly there is out-migration from the rural sector, often by those residents who can best afford to migrate, thus potentially diminishing the impetus to improve development and services to the rural sector. This process has left the Town and Country Development Planning Office wondering "to what extent declining

tenantries are viable as future residential areas given their poor accessibility to services and employment" (1988, p.44). Subsequently, the population shift contributes to the increasing overcrowded status of the urban sector, and widening the socioeconomic disparity between the two regions. Improvement of housing in the urban sector is then hampered by impossible demands secondary to the population density and a low rate of land ownership and subsequent limitations on upgrading utility services and the structure of the home.

Land ownership is enjoyed most by the rural peasant farmers who can barely afford home improvement anyway, and the wealthy suburbanites who set up residence out of the capital center, but still within the urban belt. As has been noted, despite the relatively larger plots of land in the heights and terraces, even the suburban sector is characterized by overcrowding. Land ownership is least prevalent in the heavy urban sector where residents are subjected to health threats and psychological stress due to overcrowding.

The implications of the current land distribution patterns regarding the asthma study are as follows: Rural residents, who own the land (probably largely out of inheritance) do not have the capital to upgrade their homes and are probably exposed to pests unique to that environment and to poor quality homes. On the other hand, residents in

the densely urban sector experience a low rate of ownership, thus dissuading them from upgrading their homes and, due to poor sanitary provisions and high population density, are likely to be subjected to their own set of household pests. Lastly, residents who are "mainstream" in regards to semi-urban or suburban residency--the stated ideal by the sample population and the overall trend according to statistics--are in fact landowners who are upgrading their homes, or "modernizing" them in such a way that probably includes the high moisture and poor ventilatory elements previously described in this thesis. They too probably have their own set of household pests, some of which, according to the guiding hypothesis in this study, are particularly allergenic and a threat to the asthmatic. The following section will address the specific features related to land ownership, home ownership, and modernization of the house, that are changing the microenvironment of the Bajan home.

Housing Patterns Among the Asthma Study Population

Ownership of Dwellings

Housing patterns among asthma study informants reflect the overall trend in Barbados. The mean length of time that a family had lived on a given lot was 19 years (median=12). The mean age of the house was 21 years, but a median of eight years indicates a tremendous range, and suggests that a number of homes had been relocated. In fact, 21 (12%) of the residents stated that their house had been moved in the

past. The greatest proportion of homes that had been relocated were for families living in St. James (N=5) and St. Michael (N=4), at 23.8% and 19.1%, respectively.

Sixty-six informants living in the urban sector (68.8%) owned their own home, while 75 informants in the rural sector (92.6%) owned theirs, and this difference was highly significant ($X^2=15.4$; 1 df, $p<0.001$) (Table 4-6). Sixteen of the informants were renting homes from the National Housing Corporation (NHC); when the data were corrected for these cases, there was still a significant difference between the urban and rural sector regarding ownership. There was also a significant difference of home ownership by residential region ($f=5.61$; $df=6, 170$; $p<0.001$) and by parish ($f=2.43$; $df=10, 166$; $p=0.01$). Specifically, the lowest percentage of home ownership was in the densely populated region (59.0%) and 100% of the peri-urban residents owned their home. Strangely, Table 4-6 indicates that only three out of the five suburban height/terrace residents owned their home; one explanation for this unexpected ratio is that informants did not consider "owned but under mortgage" as a possible response. Again, when the data were corrected for NHC renters, the same trend in regional location was observed.

Table 4-6. Home ownership patterns according to demographic region (N=177).

Region	Frequency	Percent
Densely populated (within 2 miles of Bridgetown)	26	59.0
Semi-urban	29	74.4
Peri-urban (in urban district, visible agriculture)	11	100.0
Suburban height/terrace	3	60.0
Rural tenantry	70	93.3
Government housing, rural	0	0
Mixed rural (tenantries & suburban heights/terraces)	2	100.0
TOTAL	141	N/A

The parishes with the highest proportion of home ownership were similar to the parishes with the highest proportion of land ownership and included the very rural parishes of St. Joseph, St. Andrew, St. Lucy, and St. John, the suburban parishes of St. Thomas, St. Philip, St. George, and to a lesser degree, Christ Church. Table 4-7 provides a breakdown of home ownership by parish, demonstrating that St. Michael and St. James had the lowest percent of home ownership.

There were no statistically significant differences in home ownership among the informants according to age, sex, marital status, occupational status, or educational level. However, wealth (according to the amenities score) was positively related to home ownership ($t=2.75$; $df=175.0$, equal variance, $p<0.001$).

Construction of Dwellings

Seventy-two of the informants (40.7%) lived in all-wood dwellings, compared to 105 informants (59.3%) who lived in concrete or mixed wood and concrete homes. Having a concrete or mixed wood and concrete home was correlated to land ownership (X^2=5.2; 1 df, p=0.02), but not correlated to home ownership. When correcting for the 16 NHC renters (because all NHC dwellings are concrete), there was still no significant difference between home ownership and concrete or mixed concrete construction. This peculiarity can be explained in that some informants were renting homes, probably in which concrete was already part of the building and also because there are more homeowners than landowners in general. Living in a concrete or mixed structure was highly correlated to socioeconomic status according to the amenities score (t=5.72; df=173.9, unequal variance, p<0.001). Also, a concrete/mixed home was correlated to a higher occupational status of the informant (f=9.54; df=1, 175; p=0.002) and to legal marriage (f=4.49; df=1, 175; p=0.04), but not related to age, sex, or educational level of the informant. It was not related to type of neighborhood (e.g., suburban, urban), demonstrating that a number of persons living in both the urban and rural sectors, when they have the capital, are adding concrete structures to their homes. Similary, having a concrete or

Table 4-7. Frequency and percentage of informants owning their dwelling, by parish.

Parish	Homeowners: Frequency by parish	Homeowners: Percent of ownership for individual parish	Non-Homeowners: Frequency by parish	Non-Homeowners: Percent of ownership for individual parish
Christ Church	9	81.8	2	18.2
St. Philip	11	91.7	1	8.3
St. John	18	94.7	1	5.3
St. George	8	100.0	0	0
St. Joseph	3	100.0	0	0
St. Andrew	4	100.0	0	0
St. Lucy	11	100.0	0	0
St. Peter	16	80.0	4	20.0
St. James	12	66.7	6	33.3
St. Michael	41	65.1	22	34.9
St. Thomas	8	100.0	0	0
Total	141	N/A	36	N/A

mixed home was unrelated to parish and urban/rural residency, even though concrete in the home is related to land ownership. It can be concluded that, based on the asthma study, the upgrading of homes is, on the whole, irrelevant to locale in Barbados. One explanation for this conclusion is that the sample size was too small to determine a significant difference between the urban and rural sector. However, another plausible explanation, based on empirical, ethnographic observations is that a number of residents are upgrading their homes prior to purchasing the land, possibly with the intent to purchase, or the security of knowing they have the option to buy the land rather than be evicted. Table 4-8 illustrates that, of the three variables--wealth, home ownership, and land ownership--the "amenities" score is most associated with concrete in the dwelling, followed by land ownership.

Table 4-8. Comparison of housing quality (concrete or mixed structure) by wealth score, home ownership, and land ownership.

	Concrete Walls		
Variables	Correlation Coefficient	df	p-value
Amenities	t=5.72	173.9	p=<0.001
Land ownership	X^2=5.17	1	p=0.02
Home ownership	X^2=1.92	1	p=0.17

Having a concrete or mixed wood and concrete dwelling was predictive for a number of structural variables. It was correlated to the presence of an indoor shower (X^2=97.2; 1

df, $p<0.001$), an indoor toilet ($X^2=88.0$; 1 df, $p<0.001$), and the total number of water taps inside the house ($t=8.92$; $df=174.0$, unequal variance, $p<0.001$). Concrete in the home was associated with a greater number of windows ($t=3.71$; $df=174.9$, unequal variance, $p<0.001$), having a finished ceiling ($f=12.24$; $df=1, 175$; $p<0.001$), the likelihood of having a concrete foundation ($X^2=104.8$; 5 df, $p<0.001$), and having a crawl space beneath the house ($X^2=12.4$; 1 df, $p<0.001$). Also correlated to concrete were the number of bedrooms in the house ($t=2.19$; $df=124.2$, unequal variance, $p=0.03$) and the total number of rooms in the house ($t=7.97$; $df=172.7$, unequal variance, $p<0.001$). Informants with concrete and mixed dwellings did not have carpeting in their home more frequently than did those informants in wood dwellings, but they did have more rooms with carpeting ($t=3.17$; $df=173.7$, unequal variance, $p=0.002$). Table 4-9 illustrates the frequency and percentage by material of the dwelling for some of these features.

In summary, the data illustrate a definite trend in the development of Barbadian housing. It is evident that, in the event a family owns the land--either by purchase or inheritance--and sufficient capital is available, concrete is added to an existing dwelling, or a new concrete dwelling is built instead. Ownership of the house is not directly associated with the upgrading of the home, probably because a number of informants who own their home do not own the

land; ownership of land is legally required in the event that concrete is used, since a permanent fixture is created with the use of concrete. There is evidence that some homeowners are adding concrete to the home prior to purchasing the land, possibly with the intent to buy the land in the near future.

The importance of building homes with concrete is both directly and indirectly significant in regards to allergies to household pests. As described in Chapter Three, a number of microenvironmental factors contribute to the development of excessive indoor moisture and decreased indoor ventilation, including water-producing elements (e.g., showers, kitchen activities such as dishwashing and cooking, and indirect contact with the ground via foundations and crawl spaces) and climate control. In the asthma study, data indicate that, with the addition of concrete, there is a greater likelihood of having more indoor water taps, a concrete foundation and a crawl space, all of which are moisture-related factors, and there is a greater likelihood of having a finished ceiling, which may result in decreased ventilation, particularly in the absence of climate control (e.g., dehumidifiers, air conditioning). Moreover, the concrete home is larger with more rooms, and provides a larger microhabitat for pests. In summary, the implications for the increasing integration of concrete in Barbadian homes are an increase in indoor moisture and decreased

indoor ventilation, which in turn provide an ideal environment for molds, fungi, and house dust mites, and possibly other types of pests unbeknown at this point.

<u>Structural Features and Demographics</u>

The fact that each individual contributes a significant proportion of moisture to the indoor environment--both physiologically and in activities of daily living--implicates the importance of household density on indoor moisture levels. In the asthma study, household density was not correlated to home ownership. However, it was weakly and inversely related to the degree of wealth ($r=0.19$, $p=0.02$), inversely related to occupational status ($f=2.04$; $df=7, 169$; $p=0.05$), and inversely related to the age of the informant ($r=0.15$, $p=0.04$), suggesting that the younger informants lived in extended family environments. Household density was not related to gender, union status or educational level of the informant, nor was it related to the region or parish of residence for the household.

Household density was related to certain structural variables of the dwelling. The relationship between high density and wood homes was statistically significant ($t=2.47$; $df=122.4$, unequal variance, $p=0.02$), and higher density homes were less likely to have indoor showers ($t=2.09$; $df=104.9$, unequal variance, $p=0.04$), indoor toilets ($t=2.69$; $df=101.3$, unequal variance, $p=0.008$), and fewer water taps indoors ($r=0.28$, $p<0.001$). High density homes

had fewer windows ($r=0.25$, $p<0.001$), and had more unfinished ceilings (or rather, a greater percentage of exposed rafters) ($f=2.62$; $df=7, 169$; $p=0.01$). These findings suggest that a high household density level is not a characteristic of adding concrete to the home, a factor that might indirectly reduce the moisture level in concrete and mixed concrete homes; upgrading the home appears to result in lower household densities.

Aspirations of the Study Population: The "Ideal" House

Informants were asked to answer questions about what they believed to be the "ideal" house, or their "dream house", so as to determine aspirations--and the presumed direction--in modernization of the house (note: 10 persons did not answer this category of questions; $N=167$). Questions were asked in open-ended style, thus avoiding any suggestion of expected answers. The majority of persons (78.4%) believed that concrete was the best building material for a house; 26 persons (15.6%) preferred wood, five (3.0%) preferred brick or limestone, and five (3.0%) would build a mixed (concrete and wood) house. Preference for concrete in the "ideal" house was not related to the presence of concrete in the respondent's current house

Table 4-9. Structural features of the dwelling by the type of material the dwelling is constructed, and for the total number of dwellings, for the asthma study households.

Structural variable	All-Wood Dwelling		Concrete & Mixed		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Dwelling ownership	61	84.7	80	76.2	141	79.7
Land ownership	30	41.7	62	59.0	92	52.0
Age of the home						
average (years)	21.7	N/A	20.3	N/A	20.9	N/A
range (years)	2-70	N/A	1-81	N/A	1 - 81	N/A
Type of foundation						
soil	1	1.4	0	0	1	0.6
coral rock/mix rock	66	91.7	44	41.9	110	62.1
limestone/concrete	5	6.9	61	58.1	66	37.3
Presence of an indoor shower	14	19.4	97	92.4	111	62.7
Presence of an indoor toilet	16	22.2	96	91.4	112	63.3
Number of bedrooms						
average	2.7	N/A	3.1	N/A	2.9	N/A
range	0-7	N/A	1-6	N/A	0 - 7	N/A
Total number of rooms						
average	7.1	N/A	11.4	N/A	9.6	N/A
range	1-22[a]	N/A	4-27	N/A	3 - 27	N/A

Table 4-9 --- continued.

Structural variable	All-Wood Dwelling		Concrete & Mixed		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Household density (# occupants per # bedrooms)						
average	2.3	N/A	1.9	N/A	2.1	N/A
range	1 - 8[b]	N/A	0.8-4.7	N/A	0.8 - 8	N/A
Indoor carpeting	37	51.4	66	62.9	103	58.2

[a]Denotes an unusual case in which an informant and her offspring were living in 2 combined wood houses, situated side-by-side, sharing all facilities and rooms, thus counted as 1 household.

[b]Accounts for one home consisting of one room shared by two people, without a designated bedroom.

(f=1.05; df=1, 165; p=0.3), nor wealth, land ownership, home ownership, or urban/rural residency.

The majority of the respondents (76.5%, N=127) thought that having a pitched roof was best, mostly because a pitched roof is "attractive" (46.4%), followed by the fact that its "hurricane-proof" (22.9%). Choosing the shape of the roof for ventilatory purposes was the third-most common response, at 18.7%, followed by the response that "water runs off more efficiently" (6.0%). The remaining responses were ten individual responses each worth 0.6% of the total response rate.

Seventeen different window types were cited, indicating the wide variety of windows in Barbadian housing. More than half of the respondents (56.7%) preferred the "aluminum sash windows." Very few cited the traditional wood jalousies or demerara windows. The second-most preferred type of window was the three- or four-pane glass awning type ("Oran"), at 17.1%.

Regarding the foundation, 80.2% of the respondents preferred concrete. Only 20.4% would carpet their floor; the majority preferred "rubber tile" (linoleum) as a covering (44.9%). Twenty-two (13.2%) would have carpet in some of the rooms and another covering (e.g., linoleum, wood) in other rooms, raising the percentage of respondents who would have some carpet in their home to 33.5%.

The average number of bedrooms cited as the "ideal" number was 3.7 (median=4, mode=4). The preferred number of bedrooms was correlated to the actual number of bedrooms ($r=0.16$, $p=0.04$); people who already had a lot of bedrooms would prefer to have a lot of bedrooms in their dream house. But the preferred number of bedrooms was not related to household density, implying a sense of satisfaction even in crowded households.

It is apparent from the sample population that the majority of householders believe that the ideal house is a concrete house. Aesthetics appear to play a greater role in architectural preference than ventilatory principles (e.g., the reason for choosing a certain roof-type or window-type). The implication here is that personal aspirations are concurrent with the apparent direction of Barbadian housing.

Discussion and Summary

Figures 4-1 and 4-2 are a presentation of the interrelationships between the various structural and demographic variables. Because the independent variables were categorical, ordinal and interval, which necessitated various bivariate analyses (Chi-square, Pearson correlation, t-test, and ANOVA), the first (Figure 4-1) correlation matrix presents the p-values, and Figure 4-2 presents the Chi-square/Pearson's r/T-/F-values (correlation coefficient). At a glance, the matrices indicate that, in regards to intercorrelation, wealth is the strongest

variable, followed by concrete/mixed walls, foundation quality, the percent of a finished ceiling, the number of indoor water taps, the presence of an indoor shower and toilet, and the number of rooms.

Interestingly, urban/rural residency plays a very marginal role in determining the quality and upgrading of homes, even though regional variables were important in determining land and home ownership. A very significant finding in this study is the percentage of concrete/mixed dwellings despite the absence of home and particularly land ownership. Possible explanations for this phenomenon have been discussed.

The matrices and several of the "aspiration" responses indicate a solid trend in the upgrading of the home, that involves the addition of water sources following the construction of concrete, an increase in the number of rooms, and a subsequent decrease in household density. As described under "Health Implications" in Chapter Three, household density affects the humidity level in the home. However, homes with lower densities expectedly compromise their "lower moisture factor" advantage by virtue of the fact that they have indoor sources of water that poorer, high density homes do not have (e.g., shower, toilet, kitchen sink), and are more likely to afford other water-producing amenities such as a washer or dryer. In contrast, the higher density, poorer wood homes have their own sources

of moisture; in addition to moisture produced from human activities of daily living, wood has been implicated as a source of moisture build-up, and wood homes are more likely to have soil crawl spaces, a site of moisture production. But traditional wood homes are notoriously the better-ventilated homes (e.g., traditional windows, unfinished ceilings with exposed rafters) and, according to Hansen's work (1984), cooking, dishwashing, and bathing/showering produce more moisture than the human contribution, thus minimizing the importance of household density as a moisture-related factor.

Regarding ventilation, there are advantages and disadvantages in the trend of Barbadian housing. On the one hand, the number of windows in the home increase with the addition of concrete, but so do the number of rooms. As has been described, the areas of the home requiring the most ventilation in order to minimize humidity levels (toilet and shower area) are those where Barbadians use the smallest windows and those situated in areas of lowest air flow in the home. From reported aspirations among the asthma study informants, it would appear that the "old fashioned" windows that offered maximum ventilation are clearly out of fashion. Another trend is a finished ceiling; a finished ceiling decreases ventilation by the creation of a dead airspace between the ceiling and rafters (attic), in addition to the fact that any spaces previously between the roof and wall

are sealed off when creating the ceiling, further minimizing airflow (K. Pope,[1] personal communication).

In summary, a number of moisture-related and decreased ventilation-related factors are increasingly being integrated into the Barbadian home (Figure 4-3). Having thoroughly outlined the basis for this evolution of housing, the next logical step in this thesis is to identify the household pests present in Bajan homes, and to sort out relationships between the presence of those pests and modernization factors of the home.

<u>Notes</u>

1. K. Pope, A.I.A., Baskerville & Son Architects and Engineers, Richmond, Virginia. Mr. Pope graciously provided the blueprints and sketches (figures 3-3a-c & 3-4a-c) based on ethnographic data from the author, and site visits by Mr. Pope in 1991. Mr. Pope also provided architectural insights regarding ventilation and the lowering of the chattel house ceiling.

	urban residency	land ownership	home ownership	age of home	wealth	household density	concrete walls	foundation quality	cellar	% of finished ceiling	# indoor water taps	indoor shower	indoor toilet	# rooms	# bedrooms	# windows	# rooms with carpet
urban residency	X																
land ownership	**<0.001**	X															
home ownership	**<0.001**	**<0.001**	X														
age of home	0.93	0.52	0.25	X													
wealth	0.11	**<0.001**	**0.007**	**0.04**	X												
household density	0.54	0.27	0.20	0.45	**<0.001**	X											
concrete walls	0.21	**0.02**	0.17	0.57	**<0.001**	**0.02**	X										
foundation quality	**0.02**	**0.04**	**0.02**	0.11	**<0.001**	0.13	**<0.001**	X									
cellar	**0.001**	0.88	**0.003**	**0.003**	**0.04**	0.56	**<0.001**	**<0.001**	X								
% of finished ceiling	0.54	**0.05**	**0.09**	0.14	**<0.001**	**<0.001**	**<0.001**	**0.008**	0.81	X							
# indoor water taps	**0.06**	0.35	0.11	0.78	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.00**	**<0.001**	X						
indoor shower	0.81	0.180	0.58	0.62	**<0.001**	**0.04**	**<0.001**	**<0.001**	**0.008**	**<0.001**	**<0.001**	X					
indoor toilet	0.48	0.240	0.64	0.93	**<0.001**	**0.008**	**<0.001**	**<0.001**	**0.004**	**<0.001**	**<0.001**	**<0.001**	X				
# rooms	0.64	**<0.001**	**0.08**	0.12	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.01**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	X			
# bedrooms	**<0.001**	**<0.001**	**<0.001**	0.22	**<0.001**	**<0.001**	**0.03**	**<.001**	0.41	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	X		
# windows	0.32	**0.003**	0.14	0.77	**<0.001**	**0.009**	**<0.001**	**0.002**	0.29	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	X	
# rooms with carpet	**0.04**	0.65	0.83	0.54	**<0.001**	0.16	**0.002**	**0.004**	**0.004**	0.13	**0.010**	**0.01**	**0.003**	**<0.001**	**0.010**	**0.008**	X

Figure 4-1. Correlation matrix (p-values) for structural and demographic variables in the asthma study households. All values are p-values calculated from bivariate analyses (Pearson's r, Chi-square, t-test, & ANOVA). Values of less than 0.10 are highlighted (bold-faced).

	urban residency	land ownership	home ownership	age of home	wealth	household density	concrete walls	foundation quality	cellar	% of finished ceiling	# indoor water taps	indoor shower	indoor toilet	# rooms	# bedrooms	# windows	# rooms with carpet
urban residency	X																
land ownership	**-10.8a**	X															
home ownership	**-15.4a**	**39.0a**	X														
age of home	0.09b	0.64b	1.15b	X													
wealth	1.59b	**4.12b**	**2.75b**	**-0.16**	X												
household density	0.62b	1.10b	1.31b	0.06	**-0.19**	X											
concrete walls	1.54a	**5.17a**	1.91a	0.56b	**5.72b**	**-2.47b**	X										
foundation quality	**5.78c**	**4.15c**	**5.70c**	1.94c	**12.17c**	1.71c	**116.9c**	X									
cellar	**11.41a**	0.02	**8.7a**	**2.99b**	**2.11b**	0.58b	**12.4a**	**-37.8c**	X								
% of finished ceiling	0.61b	**1.98b**	**1.73b**	0.12	**0.44**	**-0.29**	**3.50b**	**2.81c**	0.24b	X							
# indoor water taps	**1.90b**	0.94b	1.61b	0.02	**0.55**	**-0.28**	**8.92b**	**15.33c**	**4.66b**	**0.34**	X						
indoor shower	.062a	1.79a	0.30a	0.49b	**5.89b**	**-2.09b**	**97.2a**	**63.87c**	**6.9a**	**4.56b**	**12.36b**	X					
indoor toilet	0.50a	1.40a	0.22a	0.09b	**5.80b**	**-2.69b**	**88.0a**	**73.31c**	**8.3a**	**4.78b**	**13.22b**	**148.0a**	X				
# rooms	0.47b	**4.80b**	**1.78b**	0.12	**0.66**	**-0.35**	**7.97b**	**14.42c**	**2.55b**	**0.41**	**0.34**	**11.39b**	**12.73b**	X			
# bedrooms	**-3.43b**	**3.43b**	**4.79b**	0.10	**0.30**	**-0.30**	**2.19b**	**5.96c**	0.82b	**0.28**	**0.37**	**4.08b**	**4.96b**	**0.63**	X		
# windows	1.00b	**3.04b**	1.48b	0.02	**0.40**	**-0.25**	**3.71b**	**4.03c**	1.05b	**0.29**	**0.52**	**4.12b**	**4.16b**	**0.62**	**0.54**	X	
# rooms with carpet	**2.10b**	0.45b	0.21b	0.05	**0.28**	0.11	**3.17b**	**3.64c**	**3.01b**	0.11	**0.19**	**2.58b**	**2.97b**	**0.25**	**0.19**	**0.20**	X

Figure 4-2. Correlation matrix for structural and demographic variables in the asthma study households. All values are Pearson's r-values, except when indicated by the letter "a," which represents a Chi-square value, "b," which represents a t-test value, or "c," which represents an f-value.

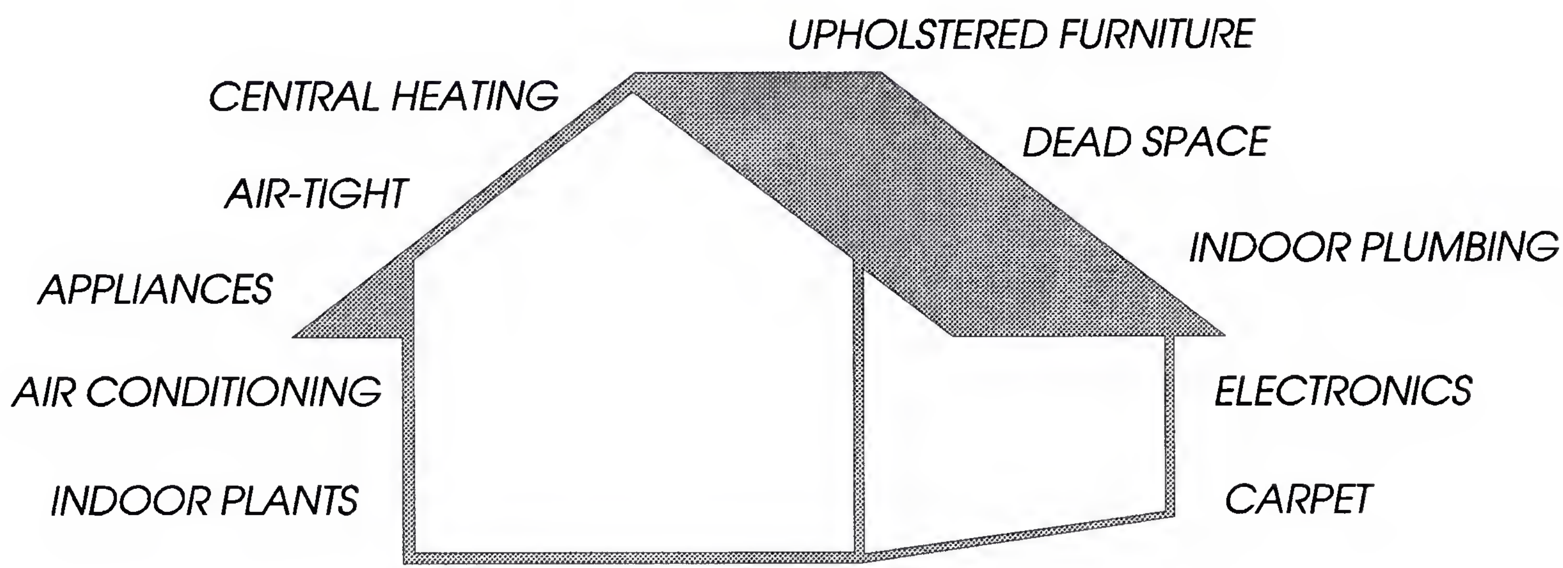

Figure 4-3. The Allergy Disease Model in the Architectural Perspective.

CHAPTER 5
NEW HOMES AND UNINVITED GUESTS: HOUSEHOLD PEST INFESTATIONS

Introduction

An important dependent factor in developing allergies to specific household pests is of course the presence or absence of those pests in the domestic environment. From the entomological survey a household pest taxonomy was created, and asthmatic children were tested for allergies to the most commonly-occurring pests. The objective of this chapter is to present a household pest taxonomy specific to Barbados, in order to identify the potential indoor arboallergens and other pest allergens to which the asthmatic is subjected. Variations in distribution of pests will be discussed at the spatial (macroenvironment and microenvironment) and temporal level and analyzed in terms of the sociodemographic and architectural variables associated with modernization of the domestic environment. How residents view pests--how they are categorized and classified (e.g., beneficial, dangerous)--and what they do about infestations, will be discussed as well. This is important in planning for control and/or eradication of pests that pose serious health threats to asthmatics.

Determining the presence of household pests is not an easy task. Expectedly, there are seasonal variations in pest infestations and monthly variations as well. Recent changes in the structure of the home may enhance or preclude a particular species living in that home at the time of analysis. A recent change in household behavior (e.g., food storage regimen), use of chemical controls (e.g., switching to a different insecticide), or a change in household density (which might lead to changes in moisture production, quantity of garbage produced, and cleanliness practices) are but a few examples of sociodemographic influences on pest populations.

Given the anticipated difficulties, and given the time constraint of one year in which to complete all aspects of the study, it was decided to qualify rather than quantify household pest infestations (with the exception of two species of house dust mites), indicating heavy infestations when possible, as well as architectural features influencing infestations, but concentrating on creating a household pest taxonomy first and foremost, so as to identify in general what Barbadians are exposed to in the domestic setting.

A significant problem in testing asthmatics to household pests was deciding <u>a priori</u> exactly what qualifies as a household pest in Barbados. While a sophisticated Ministry of Agriculture with a separate division of Entomology has functioned for some time in Barbados, limited

financial resources have mandated an agricultural focus. Household pest research and management has been left mainly in the hands of the private pest control companies, with the exception of specific pests that are notoriously a health problem (e.g., mosquitoes, rodents), for which a separate civil vector control program and an international control program (Pan American Health Organization) have been responsible.

In summary, the household pest taxonomy created from this study is based on limited taxonomic data, biseasonal trapping, information from the Entomology Section of the Ministry of Agriculture, advice from personnel at the Pan American Health Organization vector control division (the Eastern Caribbean PAHO branch is situated in Barbados), members of the Rodent Control Service at the Ministry of Health, and lastly--and certainly not least important--the residents themselves.

Infamous Household Pests in Barbados

Pests Related to Disease

Barbadians have, historically, enjoyed overall good health, largely due to the availability of a good, clean water supply and the geophysical absence of stagnant bodies of water (with the exception of Graeme Hall Swamp) that could enhance the growth and development of many tropical disease vectors. The accessibility of standing water pipes

near most homes has, in general, negated the need for holding tanks outside of the home, thereby limiting available habitats proximal to the house for pest species such as mosquitoes. Compared to other Caribbean islands, garbage collection is relatively reliable in Barbados; indeed, much of the accumulation of trash one sees in Barbados is due to negligent littering at the individual level rather than from poor garbage management at the national level. Sewerage disposal is available to the majority of Barbadians.

Mosquitoes

Despite the overall low incidence of vector-borne disease, some of the traditional tropical diseases have plagued Barbados as elsewhere in the Caribbean. The two vectors most responsible for these diseases are the mosquito and the rat. Three genera of mosquitoes have been and continue to be present in Barbados, which are potential vectors for four diseases that have inflicted largescale morbidity throughout the tropical regions: Anopheles (malaria[1]), Culex (filariasis), and Aedes (yellow fever and dengue).

The first dengue control program began in the 1950s, and no major outbreaks were recorded until 1977, when 50 persons were infected with the Type-I serovirus (Dann 1984). The incidence of dengue in Barbados has been relatively stable over the past five years (Brown,[2] personal

communication). The year-end total of "confirmed" cases dropped from 25 in 1989 to 18 in 1990 (an outbreak was reported in December, 1989[3]) (Brown, personal communication). Dr. Michael Brown, a general practitioner who specializes in dengue diagnosis and treatment, laments that, regarding preventive measures against dengue, a mosquito-oriented campaign--rather than a dengue-oriented campaign--tends to break down at the execution point. He states that mosquito fogging is "completely reactionary," and is directed toward the area from which cases are reported rather than spraying the entire island.

A PAHO/WHO-sponsored workshop "On Community Action for Integrated Vector and Rodent Control" held in April, 1990, in Barbados, drew the following response from the Ministry of Health:

> The aedes aegypti and rodent control programmes must be seen as key elements in our overall health programmes. Perhaps we have erred in the past by treating them as vertical programmes. The Ministry of Health in Barbados has sought to heighten the awareness of the community to the part it can play in disease prevention and health promotion. Greater emphasis has been placed on education via T.V. programmes, community groups, and by relevant health personnel in an effort to encourage fuller participation by all sectors of the community. Our major objective has been to change attitudes to environmental health and to show that any major changes can only occur with full participation by the individual. We are very conscious that total dependence of insecticides as a means of control cannot be successful (Yard 1990, p.2).

Other diptera

Other diptera have been implicated in disease in Barbados. Six species of the bloodsucking ceratopogonids--or sand flies (biting midges)--are known to inhabit Barbados (Greiner et al. 1990). While these diptera can be involved in the transmission of a number of pathogenic protozoa, viruses, and nematodes in both animals and humans, their disease infliction has been limited to Bluetongue virus in Barbadian sheep. Sand fly (family Psychodidae) bites are a common complaint in Barbados; however, there is no history of sand fly-related, human disease on the island (Nathan,[4] personal communication).

Lowenthal noted that dysentery was especially prevalent when cane fields were being fertilized, between July and October, during what was termed "fly season" (1957). Since Lowenthal's publication there apparently has been little or no mention of flies as a serious health problem in Barbados, although preliminary ethnographic research indicated that they are perceived as a constant health hazard in the domestic environment. There is no systematic control of flies in Barbados, with the exception of commercial control at poultry and dairy farms (Haslett,[5] personal communication).

Cockroaches

Pest control companies report that most of their calls from the private sector are for treatment of cockroaches and

rodents, the majority of their clients being of the middle- and upper-socioeconomic strata. According to the general manager of Rentokil (Barbados) Limited, the German cockroach (Blattella germanica) population is increasing in Barbados, but is still confined primarily to the commercial sector, whereas the predominant domestic problem is with the Periplaneta spp. (American and Australian) (Haslett, personal communication). Haslett confirmed that the general public was aware of the relationship between cockroach infestations and salmonella and other types of food poisoning (personal communication).

Millipedes

The diplopods--or millipedes--are perceived by the layperson as a potential danger because of the hydrogen cyanide that they exude as a defense mechanism, colloquially called a "poison." Millipede burns are a well-known phenomena, and are most commonly presented in the head and neck region, whereupon the victim--usually a child--has brushed the arthropod from the body during sleep (Harwood & James 1979). Although they prefer damp, dark habitats and feed on decomposing vegetation, they are frequently found in Barbadian homes, entering the dwelling through windows, doorways, or voids between the roof and wall. Three different types of millipedes have been recognized in Barbados, although they have not been identified by taxonomists. The smallest is referred to as the "Christmas

Worm," followed by a "medium-sized" species, and also a very large red-brown species, apparently common in gullies (Fraser et al. 1990).

Centipedes

Of greater concern to Barbadians--perhaps because of their speed--are the Chilopods, or centipedes. Two types of centipedes have been recognized in Barbados by the Caribbean Agricultural Research and Development Institute (CARDI) (both of the genus Scolopendra), but only one has been identified to species (S. subspinipes Leach) (CARDI 1985). Centipedes, unlike millipedes, have poisonous claws, or "maxillipeds," used to sting and paralyze their prey; however, the supposed neurotoxin injected by the centipede has never reportedly killed a human, and the immediate pain from the sting typically disappears in a short period (Harwood & James 1979).

House dust mites

As previously discussed, Pearson and Cunnington (1973) found house dust to be a important allergen to asthmatics, and numerous house dust mite species were identified as a major component of the dust samples. They found a total of 23 species of mites, the most predominant of which was Dermatophagoides pteronyssinus. Dust was collected from bedrooms and mattresses, and skin tests were conducted using extracts from seven of the mite species; they found that a relationship existed between the density of D. pteronyssinus

mattress infestations and the incidence of allergy to that species (Pearson & Cunnington 1973). The scientists concluded the following:

> Barbadian houses are most commonly small single-storey wooden structures containing two to four rooms and are supported on either coral or concrete blocks about a foot above the ground. These provide a damp course,...[and] The conditions are, therefore, especially suitable for the growth of many mite species, particularly D. pter.. (Pearson & Cunnington 1973, p.304-305).

After the Pearson and Cunnington study, there was a void in follow-up research on allergy to house dust mites in Barbados, as well as efforts to control populations. As of 1991, pest control companies never mention acaricides as a form of household pest control, and none of the informants in either phase of the asthma study discussed control of the house dust mite per se; only rarely did parents of asthmatics mention controlling "dust" in the house as a routine practice to minimize their child's asthmatic attacks. Reflective of its microscopic size, the house dust mite is apparently invisible in the minds of most Barbadians as a real household pest. Nevertheless, their deleterious effect on health was vividly depicted in the Pearson and Cunnington study.

Rodents

Like any other seaport in the world, a common pest in Barbados is the rat. Institutionalized control of the rat can be traced to at least since 1745, when an act was passed in which each parish church warden was required to pay a twopence bounty for every rat head delivered to him; possibly due to oversupply, the bounty was reduced to one penny in 1867 (Dann 1984). It is estimated that 654,459 rats were destroyed between 1874 and 1879 (Dann 1984).

The three rodent species in Barbados are Rattus rattus, R. norvegicus, and Mus musculus. In Barbados, rodents are both disease carriers and agricultural pests. Rodents are responsible for serious decreases in tonnage of cane because they destroy the inner nodes of young cane when it starts producing sugar (Williams,[6] personal communication). In 1974, losses due to rats cost an estimated US $2.25 million to the sugar industry (Williams 1984).

Rodents in Barbados have been implicated in gastroenteritis, salmonella, and leptospirosis. Leptospirosis is a particularly serious disease in Barbados and the other Caribbean islands.[7] Humans acquire the Leptospira spirochete via infected rats, either directly by rat bites, or, more commonly, by contact with infected rat urine. The leptospires pathogenic to humans and animals generally fall under the species name of L. interrogans, and are divided into at least five different serotypes and

various serovars, and a number of them are present in Barbados.[8] The organisms are localized in the kidneys of wild rodents--rarely fatal to the vector--and are excreted in the urine. It is estimated that as many as 10-30% of the rat population is infected with pathogenic leptospires, and as many as one million leptospires per milliliter may be excreted by an infected animal (Boyd & Hoerl 1981).

Leptospirosis was first reported in Barbados in 1939 (Yard 1990). Between November 1979 and December 1982 there was an annual average of 43.6 cases; however, this figure was unusually high, as the typical average is 17.6 per year (Everard et al. 1984). The crude incidence rate is 15-23 per 100,000, and from 1979 to 1982 the overall fatality rate was 18.8%, with an average of 8.2 deaths annually (Everard et al. 1984). In a subsequent study, the mortality rate was much lower, at 5.7% (Edwards et al. 1990). Because acquiring the disease is an occupational hazard for cane laborers and workers in small animal husbandry (because these workers are more likely to be exposed to rats and their urine), the rate is typically higher among males, and the incidence of disease increases for both sexes with an increase in age, up to 60 years[9] (Everard et al. 1984).

In 1978, a veterinary public unit was established at the Ministry of Health to better control and coordinate activities related to food borne and zoonotic diseases. As part of this project, a rodent control unit was founded

(Browne,[10] personal communication). Similarly, a leptospirosis research project was implemented during 1979-1989, and the Leptospira Laboratory has continued research in Barbados and elsewhere in the Caribbean, funded by the Medical Research Council of Barbados and the Royal Tropical Institute of Amsterdam.

Pests Not Related to Disease

During the preliminary phase of the study, several pests were repeatedly mentioned, although they were not associated with any disease. Perhaps one of the most-frequently listed pests not related to illness is the termite, colloquially referred to as "flying ants," or "rain flies." CARDI recognizes seven different species of termites in Barbados (1985), but apparently the most common species is *Nasutitermes costalis*, which is primarily a tree and canefield dweller rather than a domestic species, and *Coptotermes havilandi*, the main destroyer of wood homes (Fraser et al. 1990). Seasonal relocation missions by the secondary reproductives of a colony are realized by massive swarms in search of a new home; the swarms are attracted to artificial light in the evening and invade homes *en masse*, forcing residents to turn off all lights immediately and wait for the swarm to pass on to another home. The colloquial name for the termite is attributed to the season in which these flights occur; Barbadians associate the

passing of a swarm with eminent rain, and refer to the insects as "rain flies" (Fraser et al. 1990). However, the author experienced swarms of "rain flies" in her own dwelling throughout the year and not during specific seasons.

In the late 1800s the East Indian mongoose (Herpestes auropunctatus) was introduced to the British West Indies as a control measure against rats destroying the cane. Erroneously, many assume that the mongoose was imported to rid the island of the snake population; this is true only for St. Lucia, where the project failed to eliminate the deadly "Fer de Lance" cane snake (Fraser et al. 1990).[11] The mongoose has, nevertheless, probably inadvertently affected the snake population in Barbados, no doubt disrupting a link in the ecosystem. The mongoose includes in its diet small animals such as chicks and eggs and is a nuisance to residents who own livestock.

Another Old World importation that is viewed as more of a nuisance than a benefit is the African Green Monkey (Cercopithecus aethiops sabaeus), brought from West Africa during the slave trade. Currently the monkey population is between 5,000 to 10,000 (Baulu et al. 1987). Having no natural predators or means of population control, the monkey has, in the past, been a target of bounty control. The opening of the Barbados Wildlife Preserve by Canadian primatologist Jean Baulu has re-directed the economic

interest of monkeys in the areas of tourism and medical research; many of the animals are exported for research, particularly the development of vaccines. Only a portion of the monkeys live within the domains of the Reserve, and the remaining free-roaming monkeys are a constant threat to kitchen gardens, fruit trees, and other cultivated foods, particularly in the rural regions of the island, and are considered to be a pest.

At least six species of bats are known to occur in Barbados. Their greatest health threat is the accumulation of guano in rafters and attics, which in turn attract cockroaches as a food source (Ebeling 1975). As in so many other cultures, bats evoke a collage of myths and stories and are often feared by the layperson. One myth is that the nocturnal attributes of bats can be passed on to watch dogs if the dogs are fed "dried powdered bat" mixed in their food (Fraser et al. 1990). A colloquial term for bats--and more frequently used than the word "bat"--is "moth." Conversely, the lepidoptera-type moth is referred to as "bat."

The Pest Collection: An Inventory of Household Pests

Materials and Methods

As described in Chapter Two, entomological samples were collected bi-annually, during the dry and rainy seasons. Traps were set for a period of five days at each time period and checked and replaced every 24 hours. The villages in which the testing took place were Oistins (Christ Church),

Cotton Vale (St. Philip), Chalky Mount (St. Andrew), Rose Hill (St. Peter), and Chapman Street Village, Bridgetown (St. Michael).

The following paragraphs describe the trapping methods that were employed. All pest specimens were removed from the trap and mounted, preserved in alcohol, or frozen for later identification. Specimens recorded by sight were listed at the time of the sighting. Trapped rats were etherized and blood was collected for use by the Leptospira Laboratory. In the event that any other animal was caught in the live trap, it was identified, the information recorded, and the animal was freed.

Light/CO_2 trap

A light/CO_2 trap was used for collecting mosquitoes and other diptera outside of the home. The traps were set proximal to the most frequented entrance of the house. The trap design included an upper container for dry ice (the CO_2 source) and a light source above the collection tube. The trap was run by a 24-volt battery that operated for a maximum of 72 hours. Due to the prohibitive cost and limited accessibility of dry ice, the trap was only run for a 24-hour period with dry ice and the light source, followed by a 24-hour period with the light source only.

Flea trap

The Happy Jack[12] brand flea trap was used over a five-day period. The trap was placed in the living room, on a carpeted area when available; otherwise the trap was placed closest to a piece of upholstered furniture or a rug. The trap consisted of a collecting pan, which was filled with water and topped with vegetable oil, and an upper pan under which a light source was suspended. Electricity was available in all of the homes selected, although presence or absence of electricity was not a criteria for selection.

Fly strips

Yellow, adhesive strips[13] were used for the collection of flies and other diptera in the kitchen and dining area. Four strips were hung in each home and changed as needed, for a five-day period. The strips were hung next to the kitchen entrance, near a food-handling area in the kitchen, and over the dining table.

Cockroach traps

Two types of cockroach traps were used. The first trap was a newly patented trap designed by Dr. Jeffrey Jones at the Ministry of Agriculture (Flick traps,[14] Flick Laboratories 1991), specifically for the *Periplaneta spp.*. The trap consists of a disc with four flap-door entrances, which cannot be opened from the inside. A well inside the trap is filled with toxic bait. The top of the trap is a

child-proof, twist-on top. The other trap used was the sticky, tent-style trap. While this trap is designed specifically for cockroaches, it catches any crawling insect or pest (e.g., mice, small reptiles). Both types were set in the kitchen (refrigerator and garbage collection), bathroom (indoor or outdoor, depending on the home), and near an entrance. Traps were replaced daily as needed and employed over a five-day period.

Live trap

Three live-catch rat traps[15] were used at each home. The traps were set outside of the house, close to the kitchen door, under the house, and in/around vegetation proximal to the house. Bait consisting of peanut butter on a cracker was placed inside each trap, as suggested by Dr. C. Everard of the Leptospira Laboratory.

Mite sampling

Dust collections. A hand-held vacuum cleaner with an built-in collection chamber was used for the purpose of collecting dust samples. The chamber was inserted between the hose and nozzle and consisted of a circular screen which supported a coffee filter (8-cup size) (Mr. Coffee Inc.[16]) for the purpose of trapping the dust. Dust samples were collected from four sites in each home: A bedroom mattress; the bedroom corner (preferably on a rug); the most-frequently used piece of upholstered furniture in the living

area; and a corner in the living area (preferably on a rug or carpeted corner). The dusting lasted for five minutes at each site and included approximately 1 m^2 of surface area at each site. A separate filter was used for each site, and each filter was placed in a zip-lock bag, labeled, and frozen. Sites were vacuumed once in both the dry and rainy season. Unfortunately, it was not possible to repeat vacuuming in six of the homes during the rainy season, due to noncompliance (refusal to continue participation by five informants, and an unknown, change of address for another informant).

Assay of the mite allergen and mite counts. House dust was kindly analyzed by Dr. E. Caldas-Fernandez and Mr. W. Trudeau (University of South Florida, Tampa, FL), for two species of house dust mites, Dermatophagoides pteronyssinus and D. farinae, using the ELISA protocol for quantification of the major dust mite antigens for Dermatophagoides spp., Der p I and Der f I. For each sample, a polystyrene microtiter plate (Dynatech Immunlon II) was coated with 1 um/well of either 5H8 (Der p I assay) or 6A8 (Der f I assay) in 0.1M bicarbonate buffer (pH=9.6) and left overnight at 4°C. Afterwards, the plates were washed twice with PBS/0.05% Tween 20 (pH=7.4) (phosphate buffered saline, containing 0.05% Tween 20), then incubated at room temperature for 30 minutes with 0.1 ml 1% BSA PBS-T, then washed twice with PBS-T and dried.

Next 0.1 ml of the diluted allergen sample (dust) was added and incubated for one hour. Double dilutions of a reference D. pteronyssinus and D. farinae extract were used to make a control curve, which contained from 250-0.5 ng/ml Der p I and Der f I.[17]

The plates were washed five times with PBS-T, then incubated for one hour with 0.1 ml 1/1000 dilution of biotinylated 4Cl. This monoclonal recognizes a cross-reacting epitope on both allergens and is used as a second antibody for both Der p I and Der f I assays. Next the plates were washed five times and incubated with 0.1 ml 1/1000 dilution of Streptavidin-Peroxidase (Sigma S5512) for 30 minutes. The plates were washed again five times and assays were developed by adding 0.1 ml 1mM ABTS in 70mM citrate phosphate buffer (pH=4.2). The reaction was stopped after five minutes by adding 0.1 ml 2mM sodium azide.

Absorbance was read at 414nm in an ELISA microplate reader. Absorbance readings were directly proportional to the quantity of either Der p I or Der f I bound and values were extrapolated from the respective control curves.

Results: Collective Taxonomy of Barbadian Household Pests

The completed household pest inventory is presented below. Pests were identified to species when possible or the closest level thereafter. With the exception of the live-trap animals, reptiles, amphibians, and cockroaches (identified by the author), pest identification was

graciously completed by L. Davis (USDA/ARS, Gainesville, FL), entomologists from the State of Florida Division of Plant Industry,[18] Dr. T. Walker (University of Florida, Gainesville, FL), and E. Fernandez-Caldas and W. Trudeau (University of South Florida, Tampa, FL). As stated, only the house dust mites were quantified; the remaining pests were simply identified to the closest taxonomic level possible, and spatial and temporal distributive characteristics were noted as appropriate.

Each of the 20 homes was considered for the pest survey, except in the case of the house dust mite analysis; as will be presented, three of the homes were deleted for that aspect of the study. Of the twenty homes, twelve (60.0%) were urban and eight (40.0%) were rural. The average amenities score for the sample was slightly below that of phase II, at 17.0 (median=15). The mean household density was 1.7 (range= 0.5-4), which is consistent with national figures. Eight homes (40.0%) were all wood, nine (45.0%) were mixed concrete and wood, and three (15.0%) were entirely concrete.

Rodents and other mammals

Rats were trapped on only three of the twenty homes, although all residents reported seeing rats in the neighborhood sometime in the past. *Rattus norvegicus* was trapped most frequently; two *Rattus rattus* were trapped throughout the study. During the dry season, a rat was

caught everyday from one of the highest-quality homes--a concrete home in Oistins. The family raised chickens directly behind the kitchen, on the patio/balcony, and commented that rats were a constant problem to the coops. In none of the homes did residents report using rat poison or other means of rodent control. Rats were trapped in only two of the five villages--the highly urban villages of Chapman Street (Bridgetown) and Oistins.

Mice (<u>Mus musculus</u>) were caught in four of the homes. In each case they were trapped on the "tent"-like sticky trap, either in the kitchen or in the bathroom. For those homes in which mice were trapped, there was poor containment of garbage at the trap site. Similarly to rats, mice were trapped in urban homes only (Chapman Street, Oistins, and Rose Hill).

The East Indian mongoose (<u>Herpestes auropunctatus</u>) was caught in the live trap in five different homes, in all of the villages except for the most urban village of Chapman Street. In one of the homes in Rose Hill, a mongoose was trapped nearly everyday of the survey; the household raised ducks and complained of the mongoose attacking the eggs on a regular basis. The mongoose was observed in every village, including Chapman Street.

The African Green Monkey (<u>Cercopithecus aethiops sabaeus</u>) was sighted frequently in the very rural village of Chalky Mount. It was most commonly seen in the early

morning hours, feeding off of the fruit in the trees. A number of villagers in Chalky Mount complained that they could no longer maintain a kitchen garden in Chalky Mount, because the monkey destroyed the garden before its yields could be harvested for human consumption. The animal was not sighted in any of the other villages.

Orthoptera

Cockroaches (Periplaneta spp.) were the most consistently-found pest in the study, except for the house dust mite. They were recovered in 15 of the 20 homes, primarily on the sticky trap;[19] P. americana was found in fourteen of the homes, and P. australasiae was found in eight of the homes. In one home (Cotton Vale, St. Philip), the Surinam cockroach (Pycnoscelus surinamensis), a feral species, was found in the kitchen trap. Periplaneta spp. were found in all of the Oistins homes and in three of the Chapman Street (Bridgetown) homes. They were found in smaller numbers in three of the Cotton Vale homes, in three of the Rose Hill homes, but found in only one of the very rural Chalky Mount homes. This finding illustrates their affinity for the urban district, where food sources and preferable habitats are abundant.

German cockroaches (Blattella germanica) were found only in two homes--one home in Chapman Street village and one in Oistins. In both homes, the insects were trapped in the concrete sections of the home (both homes were mixed

concrete and wood), near poorly contained garbage. The German cockroach was found in large numbers in the Chapman Street home; it is important to note that Chapman Street Village lies in the center of commercial Bridgetown, near grocery stores and other businesses where the insect could easily be imported via boxes and cargo.

Also found were two species of crickets, one of which had not been identified previously in Barbados, *Gryllodes sigillatus*; the other was *Acheta assimilis*. A Grass Mantid (family Mantidae) was trapped, but could not be identified to species.

Coleoptera

A few beetles were found in the homes. Of significance, the bruchid *Callosobuchus maculatus* was identified; this is a stored food pest, that typically feeds on cowpeas, pigeon peas, and other legumes, a staple in the Bajan diet.

Amphibians/reptiles

Geckos are common in Bajan homes, and were trapped in four of the homes, in Oistins, Rose Hill, and Chapman Street. *Hemidactylus mabouia* is typically seen after sunset, because it clings to walls and feeds on insects attracted to artificial lights; probably for this reason the animal was never spot-sighted. The common green lizard (*Anolis extremus*) was trapped in seven homes; a specimen was recovered in all of the villages except for Chapman Street.

It is believed that these animals were accidentally caught in their effort to catch an already-trapped insect on the sticky traps.

It was not uncommon to find a *Bufo marinus*, the only species of toads in Barbados, inside one of the live traps outside of the house. The toad was found in three of the four Oistins homes, and recovered in three villages: Oistins, Cotton Vale, and Rose Hill.

Diptera

House flies (*Musca domestica*) were observed in every home in each village, although they were sighted with much greater frequency in homes with fowl and stock (N=12) around the house than in those without fowl and stock. From the CO^2/light traps, the following families of diptera were found: Sciaridae, Psychodidae (moth flies and sand flies), Tipulidae, Chloropidae (*Drosophila* spp., a vinegar fly), Muscidae, and Culicidae, including *Culex* spp. of mosquitoes and *Forcipomyia* spp., a biting midge.[20] Diptera collected from other traps included *Acalyptrata* spp., Phoridae (*Megaselia* spp.), Ceratopogonidae (*Atrichogogon* spp.), and Eolichopodidae. Most of the Psychodidae were of the *Psychoda* spp.; these species are not bloodsuckers, but can be a considerable annoyance around washbasins in bathrooms (Harwood & James 1979). Most of the Muscidae were *Musca domestica* L. and *Hydrotaea* spp. (a blood-feeder). The greatest number of diptera were retrieved in the urban and semi-urban villages of Chapman Street and Oistins.

Hymenoptera

The evaniid wasp, Evania appendigaster, was trapped in six of the homes, in three villages (Oistins, Cotton Vale, and Chapman Street). E. appendigaster is harmless to humans, incapable of stinging, yet parasitizes cockroach eggs; the insect was found in six of the homes in which Periplaneta spp. were found. It is important to note that E. appendigaster does not parasitize German cockroaches (Brenner, personal communication).

Ants (family Formicidae) were very common and seen in and around all of the homes. They were trapped most-frequently in outhouses and also around garbage collection areas. Species found included Odontomacus spp., Paraturchina spp., and Camponotus spp..

Isoptera

Termites were trapped in eight of the homes, in three villages (Oistins, Cotton Vale, Chapman Street). They were found in every home in Cotton Vale, in all house-types (wood, mixed wood and concrete, all-concrete). The only species trapped was Coptotermes havilandi Holmgren (Family Rhinotermitidae, Subfamily Coptotermitinae), a species that was probably introduced into Barbados from Southeast Asia before 1930.[21]

Lepidoptera

A number of moths were trapped from most of the homes; moths were found in each of the five villages. The most common moth was the Clothes Moth (family Tineidae). Most of

the larvae of this family of moths are scavengers that feed on fungi or fabrics (Borror & White 1970). Also recovered was the Pyralid Moth (family Pyralidae), of which there are numerous species, some of which feed on stored grain or meal during the larval stage (Borror & White 1970). In addition, the Gelechiid Moth (family Gelechiidae) was recovered (some of which are known to be grain pests), the Blastobasid Moth (family Blastobasidae), and possibly the Cosmopterygid Moth (family Cosmopterygidae) (questionable identification).

Isopods

Sowbugs were found in outhouses in two of the homes, in two different villages (Chalky Mount and Cotton Vale). They were not found inside homes and were recovered in both the dry and rainy season. Cubearis murinae and Metaponorithus pruinosus were the two species identified, found specifically in Oistins and Chalky Mount.[21]

House dust mites

Two of the most important allergenic components in house dust mites that have been recognized in the immunological community are Der p 1 and Der f 1 (Group I) (Schou & Lind 1991). In the Barbados study, two species of house dust mites--D. pteronyssinus and D. farinae--were identified in the dust samples from 17 and 14 homes, respectively, using monoclonal antibodies to these Group I allergens. Three homes were deleted from the house dust mite assessment due to overall insufficient data. Total

densities, the density range, and the number of homes present were calculated for four regions in the home (mattress, bedroom floor, living room floor, and living room furniture) and for the home in general (totals were calculated for each home from the total density of the four regions in that home). Table 5-1 presents the data for the two species of house dust mites.

Of the 17 homes in the house dust mite sample, ten (58.8%) were urban and seven (41.2%) were rural. The average amenities score for the house dust mite sample was also slightly below that of phase II, at 16.9 (mean=15). The mean household density was 1.5 (range= 0.5-3.0), which is consistent with national figures. Eight homes (47.0%) were all wood, seven (41.2%) were mixed concrete and wood, and two (11.8%) were entirely concrete.

D. pteronyssinus densities did not change significantly from the dry season to the rainy season; although the mean density was 60.66 micrograms/gram in the dry season and 78.66 um/g in the rainy season, the range in each home was considerable. After conducting a GLM on ranks (SAS Inst. 1988) of density (Conover & Iman 1981) with means for season separated by Tukeys test, it was determined that there was no significant difference between any of the densities (four locations in the home plus the total density) according to season. Densities of D. pteronyssinus in the 17 households did not vary according to urban/rural residency, geophysical

location of the home, or village, and crowding of homes at the macroenvironmental level (measured by distance from the nearest neighbor) was not important. The degree of wealth of the household did not affect density levels.

Two- and three-way interactions (season, location in the home, and the presence of concrete) were not significant; consequently, a main effects ANOVA was conducted on the D. pteronyssinus data. Subsequently, densities did vary according to location within the home ($f=3.04$; $p=0.03$). An investigation of the least-square means (LSM, GLM ranked procedure) found a significant difference between furniture (the location with the highest mean densities) and the three other locations; the pair-wise t-test showed significant differences between the bedroom ($p=0.009$), living room floor ($p=0.01$), and the mattress ($p=0.07$).

Concrete homes had higher densities of D. pteronyssinus than wood or mixed (wood and concrete) according to the pair-wise T-test ($f=9.55$; $p<0.001$). However, this association should be considered with caution, because there were only two homes that were built completely of concrete, and while there was a significant difference between the wood and concrete homes ($p=<0.001$) and the mixed and concrete homes ($p=<0.001$), there was not a significant difference between the wood and mixed homes ($p=.18$).

Counts in the mattress increased with the age of the home in both the dry ($r=0.69$, $p=0.003$) and rainy season ($r=0.62$, $p=0.02$). Several other independent variables were associated with densities, but for the dry season only, and included the following: Homes with more bedrooms had higher counts overall ($r=0.52$, $p=0.05$); densities in the bedroom increased with the number of beds in a bedroom ($r=0.61$, $p=0.009$); and densities were correlated to the age of the living room furniture ($r=0.53$, $p=0.03$). Interestingly, mattress densities were not related to the age of the mattress.

Other household moisture factors did not affect the overall density of _D. pteronyssinus_, including the number of indoor water taps, an indoor shower or toilet, or the type of foundation. Carpet in the home was not an important factor in the degree of density. _D. pteronyssinus_ overall was significantly correlated to household density, but only during the rainy season ($r=0.60$, $p=0.03$); there was no relationship between _D. pteronyssinus_ and household density during the dry season.

Similarly to _D. pteronyssinus_, mean densities of _D. farinae_ in the 17 homes did not vary according to season. It is important to note that overall densities of _D. farinae_ were 1/1000 that of _D. pteronyssinus_, and were measured in _nanograms_ per gram of dust rather than micrograms per gram of dust. Also, _D. farinae_ were found less frequently in the

sample of homes; specimens were collected from only nine of the seventeen homes in the survey for both seasons. Furthermore, no specimens were recovered from homes in the densely urban sector (Bridgetown) for either season. Densities were not related to macroenvironmental crowding (distance from the nearest neighbor).

Two-way interactions ANOVA indicated a borderline relationship between densities of *D. farinae* and season and the presence of concrete; analyses suggested that there were significantly higher densities in the rainy season in concrete homes; however, a main-effects ANOVA indicated that mean densities were actually highest in the wood homes and lowest in mixed (concrete and wood). It can be argued that the extremely low counts of *D. farinae*, in addition to a small sample size, suggest that any observable associations may be spurious.

Discussion of the Pest Collection Results

Food and/or garbage pests

The common household pests, typically attracted to food and/or garbage, were abundant in Barbadian homes, and include the cockroaches, ants, flies, and rodents. The most common cockroach in the 20 homes was the *Periplaneta* spp., although *Blattella germanica* was found as well.

The ant species found in the study were primarily those attracted to sweets (*Paraturchina* spp., *Camponotus* spp.). It is possible that contact with ant-related allergens is

predominantly ingestant rather than aerosolized; crawling over foodstuffs and cooking utensils, ants, like cockroaches, have been incriminated as mechanical vectors of viable pathogens (Harwood & James 1979). In addition to pathogens, they are possibly contaminating food and utensils with frass, egg cases, and other particles which may function as allergens.

Musca domestica was particularly common, especially in those homes with fowl and/or stock around the house (12 homes). It is typical for Bajans to keep stock--especially fowl--near the house, usually in the space under the house, as a personal food source. According to the entomological survey, the raising of fowl around the home is not related to socioeconomic status; the two wealthiest households as well as the poorest household had fowl around the house. Having fowl around the home does appear to be a factor related to urban/rural residency, because none of the Bridgetown households kept fowl, and all of the Chalky Mount households had fowl. The prevalence of this pest--due mainly to human behavior (stock around the house)--implies that it is a significant component of domestic aeroallergens.

Pests dependent on human hosts

The two most common pests that are dependent upon humans for survival, and found in the Barbados study, were the two mosquitoes of the genera *Aedes* and *Culex*, and the

house dust mites (to be addressed below). All of the residents complained of having mosquitoes at one time or another; therefore, contact with these pests, both injectant and possibly via aeroallergens, appears to be relatively common.

All four of the households in Rose Hill (the village near Speightstown) complained of sand flies, although these pests were not trapped. It can be inferred, that, based on taxonomic information, as well as ethnographic data, sand flies are common in Barbados, and sand fly bites (an injectant allergen) pose an additional threat to the atopic who is hypersensitive to arboallergens.

Moisture-related pests

Moisture-related pests are those which usually feed on fungi, and live in damp cracks, crevices, and wall voids, where the habitat is favorable to their survival (Ebeling 1975). They typically include fungus beetles, gnats and moths, springtails, psocids, and certain mites; these arthropods are attracted to damp areas because of the mold and fungus that grows there (Ebeling 1975). Other arthropods, including sowbugs, centipedes and millipedes, must live in damp places because they do not have a protective lipid film to prevent a lethal rate of water loss; their preferred habitat is not necessarily the house itself, but the damp areas surrounding or beneath the

structure, and their entrance is usually accidental (Ebeling 1975).

The traps used in the study were not designed specifically for collecting most of these moisture-related pests, although some of these pests were, nevertheless, recovered. Although not identified to species, several families of moths found in the study are moisture-related pests; they include species of the Pyralid Moth, such as the Fungus Moth (Aglossa caprealis) and the Meal Moth (Pryalis farinalis), and also a species of the family Tineidae (Ebeling 1975). A number of sowbugs, millipedes, and centipedes were trapped in the study. One of the ant species (Camponotus spp.) identified in the study is also a moisture-related species, in addition to its affinity for sweet foodstuffs.

Stored food pests

Health risks associated with stored food pests include contamination with a number of pathogens (Gorham 1991), nutritional changes caused by damage (Scott 1991), and the consumption and/or exposure to arboallergens (Brenner 1991; Wirtz 1991). Stored food pests range from the minute thrips and mites to beetles, moths, ants, and parasitic wasps (Munro 1966). Several stored food pests were found in the Barbados sample, including various moths and bruchid beetles. Because the focus of this study was not stored food, it is likely that many more stored food pests exist in

Bajan homes; the traps used in the study were not specifically directed toward stored food pests.

Mites infesting food typically belong to the Tyroglyphidae, Glycyphagidae, and Carpoglyphidae families (Wirtz 1991); however, as will be demonstrated, exposure to one species of an arthropod often predisposes the atopic to develop hypersensitivity to other species of that same arthropod. Cross-reactivity also extends across different families and orders of arthropods (Baldo & Panzani 1988). The critical implication in regard to stored food pest infestations in Barbados is the problem of multiple exposure sites for highly allergenic arthropods (e.g., aerosolized, ingestant).

House dust mites

The high densities of D. pteronyssinus in Barbadian homes corresponds to findings of Pearson and Cunnington (1973) two decades ago. The extreme low density of D. farinae--and in some cases, absence of the species altogether--is also consistent with the researchers' conclusions. Similarly, in other studies, densities of D. farinae are remarkably lower than those of D. pteronyssinus when both species are found in the same locale (Charlet et al. 1978; Chang & Hsieh 1989; Colloff et al. 1991) and D. farinae is often absent (Colloff 1987a & 1987b, 1988a). A curious finding in the Barbadian setting was the total absence of D. farinae in the densely urban sector.

Densities of both D. pteronyssinus and D. farinae did not change significantly from the dry to rainy season in the asthma study, which is contrary to other studies, in which the warmest and wettest months of the year with the highest levels of relative humidity are the months in which densities are typically the greatest (Wharton 1976; Charlet et al. 1978). This probably is due to the relatively high year-round humidity level. Densities of D. pteronyssinus were correlated to factors other than outdoor climate and concrete in the home, but associations were strongest in the dry season.

Interrelationships between the density of D. pteronyssinus and numbers of different microhabitats (a high number of bedrooms and more beds) were important for the dry season only. Only the use of concrete in construction was significant in both seasons. This relationship suggests that the combination of very high relative humidity levels in the rainy season and a concrete home may supersede the importance of individual features.

The implications of the modernization process in Barbadian homes and, subsequently, an undue increase in indoor moisture and a decrease in ventilation, have heretofore been discussed. Spatial distributions of D. pteronyssinus in the current study confirm the hypothesis that the construction of concrete is an important element in the proliferation of certain house dust mite species,

Table 5-1. Density of house dust mite species D. pteronyssinus and D. farinae in 17 Barbadian homes. (Note difference in units of measurement for the two species).

Location in the home	D. pter.			D. farinae		
	No. of times present	Mean density of mites (microgram/ gram of dust)	Range	No. of times present	Mean density of mites (nanogram/ gram of dust)	Range
Dry Season:						
Mattress	16[a]	15.81	0.13-120	5[a]	11.11	1.8-44.0
Bedroom floor	17	4.23	0.02-44.8	4	10.71	44.0-50.0
Living room floor	16	1.26	0.13-5.05	7	17.86	44.0-60.0
Living room furniture	17	40.37	0.02-284.2	5	19.34	42.8-148.0
Total mean density for the home	17	60.66	0.17-287.07	9	53.21	86.8-240.0
Rainy Season:						
Mattress	14[b]	3.68	0.21-23.16	7[b]	22.99	44.0-68.0
Bedroom floor	13[b,c]	0.85	0.14-2.74	4[b,c]	16.92	44.0-72.0
Living room floor	14[b]	10.03	0.024-125	4[b]	15.0	44.0-60.0
Living room furniture	14[b]	64.17	0.15-252	4[b]	11.06	1.8-60.0
Total mean density for the home	14[b]	78.66	0.814-254.1	9[b]	64.76	88.0-240.0

[a]One sample was insufficient to determine mite density.
[b]Samples could not be repeated in three homes during the rainy season.
[c]One sample was insufficient to determine mite density.

probably because of the overall accumulation of moisture associated with concrete in housing (e.g., indoor water sources, finished ceilings, and smaller and fewer windows situated in the moisture-laden areas of the home, such as the shower stall). Individual contributors of moisture (e.g., indoor shower, number of water taps) did not bear significance in the analysis; yet the author contends that the small sample of homes (17) limited the number of independent variables that could demonstrate a relationship at a significant level. A relationship between higher counts of D. pteronyssinus and older homes, more beds in the bedroom, more bedrooms, and older pieces of living room furniture, suggests the importance of multiple microhabitats within a single home. The significance of this is of course the greater likelihood of exposure to house dust mite allergens by the atopic; the more locales in the home infested with house dust mites, the more frequently the asthmatic will come into contact with the allergens.

There was no difference in densities of D. pteronyssinus according to mattress-type. The lack of association must be considered with caution, because only two mattresses (11.8%) in the study were spring; the other mattresses (88.2%) were foam, which is the most common type of mattress in Barbados, primarily due to affordability. However, foam mattresses wear faster and are replaced more frequently than spring mattresses in Barbados; this may be

an important factor in predicting densities of house dust mites and deserves further attention.[22]

House dust mites do not tolerate relative humidity levels below 55% (Korsgaard & Iversen 1991). The relative humidity requirement for D. pteronyssinus is higher than that for D. farinae (Arlian 1975; Brandt & Arlian 1976; Wharton 1976). Hallas summarizes the interrelationship between temperature and relative humidity as follows: "Much simplified, it can be said that it is mostly temperature that decides how quickly mites can develop, whereas humidity determines the number of house dust mites able to live in a home" (1991, p.7). Relative humidity is important to mites because it is their primary source of water; this is achieved by passive and active absorption of water from unsaturated air (Arlian 1975). House dust mites, like other animals, also receive water by ingestion of their food and, of lesser importance, mites obtain metabolic water via the oxidation of fats and carbohydrates (Arlian 1977).

Although the house dust mite thrives anywhere in which there is the presence of irregular surfaces that trap dust and skin scales,[23] the bedroom--particularly the mattress--is thought to be the primary focus for breeding of the house dust mite in most homes (Wharton 1976; Colloff 1989; Colloff et al. 1991; Hallas 1991; Korsgaard & Iversen 1991). This is because the bedroom mattress provides warmth, a constant source of shed skin scales, and subsequently both food and

water. Because people spend approximately eight hours per day on their mattress, the mite has a dependable source of nutritional and metabolic provisions. An additional moisture source available in mattresses is the nocturnal sweating and body heat produced from sleeping humans; this metabolic function can increase relative humidity and temperatures to 95% and 35°C, respectively (Colloff 1989). However, Barbados densities were higher in living room furniture than in the mattress or bedroom. For reasons unknown, it appears that D. pteronyssinus, in the Barbadian setting, prefers the microhabitat of living room furniture over its more traditional habitat, the bedroom mattress.[24] This factor deserves further study.

A temperature range of 20-25°C and a relative humidity of 75-80% are optimal for the survival and growth of most mite species (Colloff 1989), although optimal levels do vary slightly according to species (Arlian 1975; Brandt & Arlian 1976). Temperature is important to mite survival primarily in regard to its effect on humidity (a proportional relationship), because, according to Korsgaard and Iversen (1991), studies have shown that temperature by itself does not affect mite counts. This is apparently true, however, for low temperatures only, as maximum tolerance levels for high temperatures have been demonstrated (Arlian 1975; Brandt & Arlian 1976).

Researchers contend that, despite the overall temperature and relative humidity, slight changes of these two elements within the microhabitat can markedly affect fecundity and migration patterns of mites seasonally, monthly, and even daily (Colloff 1991). There is evidence that this feature is magnified in the tropical setting where the annual range of temperature and relative humidity is fairly narrow (Charlet et al. 1978; Colloff 1991). In fact, this lower tolerance in species to minor fluctuations has been demonstrated _in vitro_ for populations subjected to long-term optimal conditions and then challenged with slight variations in temperature and relative humidity, after which the mortality rate was quite high (Colloff 1987c). Even in temperate climes, changes in the microclimate within the mattress causes mites to migrate to different regions of the bed[25] (Colloff 1988a & 1991).

The small sample size of homes for dust sample collections in the asthma study, and collection during two time periods in the year only, may have resulted in data too limited from which to make appropriate conclusions. Murray & Zuk (1979) found that peaks in mite populations occurred in different months over a two and-a-half year period, suggesting that additional fluctuations may have been missed in the Barbados study. However, the analyses do confirm the presence of one of the most allergenic arthropods known--_D._

pteronyssinus, and the data suggest that concrete provides a more favorable microenvironment for that pest than wood.

The Ethnographic Survey: Categorization, Classification, and Responses to Household Pests

One of the objectives in the interview schedule was to assess the worldview of Barbadians regarding household pests, by randomly selecting, from the total group of informants, a sub-group to whom questions about their own pest infestations, and household pests in general, could be asked. The purpose of this assessment is multi-dimensional. First, responses from the informants could support and supplement findings from the entomological survey, both in the household pest taxonomy, and in the investigation of relationships between infestations of pests and sociodemographic and structural variables. Second, to the author's knowledge, an assessment of the mental mapping of household pests--what constitutes a household pest, and how it should be managed--has not been investigated in Barbados. Such information can be extremely helpful in planning control strategies at all levels: International, civil, commercial, and private. Also, intensive campaigns have been conducted against two common pests in Barbados--aedine mosquitoes and rodents--to reduce the incidence of two serious diseases, dengue and leptospirosis, respectively. It is useful to assess the knowledge base of citizens regarding these two pests, in comparison with other common

pests, to determine both the effectiveness of these campaigns and, if the campaigns have been successful, to possibly apply certain aspects of these campaigns in the control of other potentially hazardous pests. Last, even though the layperson might be familiar with the name of a pest, will she/he recognize that pest in the event that contact is made with it? This factor is vital in the successful reporting of infestations to proper authorities/control personnel and in the domestic control of a hazardous pest.

Sixty-five informants were chosen randomly from the group of 177 informants to answer the household pest-related questions in the questionnaire. This section of the interview was conducted in the home because of the additional amount of time required for the questions and the use of pile sorting as an interview technique. The pile sort included a collection of 33 different arthropods and four cards with a color photo of an animal on the card; cards were used for monkey, mongoose, house dust mites, and toad, because it was not possible to obtain actual specimens. One of the arthropods--a scorpion--is not present on Barbados and was included to determine validity in recognition and recall. One of the cards--the house dust mite--is not a pest with which most laypeople are familiar and is microscopic. To parents of asthmatics, however, it

is a pest of which they have no doubt heard a great deal in the media and from health care professionals.

The sample population for the pest-related questions was composed of 64 females and one male. The average age of the informant was 36 years (median=35). The mean "amenities" score was 17.1 (median=15). Thirty-eight informants (58.5%) lived in the urban sector and 27 (41.5%) lived in the rural sector. This sub-population compares favorably with the total population. Obviously, male informants are seriously under-represented, but there were only 12 (6.8%) male informants in the total sample. The average age of the total sample was slightly lower, with a mean of 35.6 years (median=34). The amenities score for this population was slightly higher than that of the total population (mean=16.6, median=15). The urban/rural breakdown is also very similar; for the total population, 96 (54.2%) informants were urban and 81 (45.8%) were rural. Forty-nine (75%) of the informants had a child with asthma and 16 (25%) did not. In summary, the sub-population was highly representative of the total population for the study.

The Ethnographic Taxonomy

The first step in the ethnographic assessment was to determine which pests informants had most frequently in their homes and to determine their recognition of 37 household pests. When clients were asked to list all the pests that they had ever seen around their home, the average

number of pests recalled was 6.0. Only 3% (N=2) could list more than 10 pests around their home. A total of 38 different pests were listed. Cockroaches (*Periplaneta spp.*) were the most frequently listed pest (nearly 90% of the population), followed by mice (70.8%) and mosquitoes (70.8%), millipedes (60.0%), and flies (52.3%). Each of the other pests listed were reported by less than 50% of the population, and 10 of the pests were only listed by one person each. Table 5-2 presents the 37 different household pests listed and the frequency with which they were reported.

After clients were asked to "free list" all the pests that they could recall seeing around their home, they were presented with the pile sort. Eight of the pests listed were not part of the pile sort, but one of these was a domestic cat (listed by one informant only), five other arthropods were listed only once, and one was listed twice. It was concluded that the most important pest species were included in the pile sort, and the technique was believed to be valid for the population. Clients were asked to name each specimen in the pile sort, in order to determine their recognition of a pest (Table 5-3). If they recalled seeing an animal, but could not name it, the information was recorded. If the informant misidentified the animal, the answer was counted as "unable to name." Recognition was recorded according to the common name used by the informant.

Table 5-2. Reported pests in Barbadian homes by informants in the Asthma Study.

Pest	Frequency	Percent
Cockroach (Periplaneta spp.)	58	89.2
Mouse	46	70.8
Mosquito	46	70.8
Millipede	39	60.0
Fly	34	52.3
Centipede, large spp.	27	41.5
Rat	25	38.5
Ants	15	23.1
Sand fly	15	23.1
Lizard	12	18.5
Centipede, small spp.	9	13.8
Gecko	8	12.3
Grasshopper	5	7.7
Frog	5	7.7
Termite	5	7.7
Slug	5	7.7
"Giant" cockroach (Blaberus spp.)	4	6.2
Moth	4	6.2
Beetle*	4	6.2
Bat	3	4.6
German cockroach	3	4.6
Mongoose	3	4.6
Cricket	2	3.1
Sowbug	2	3.1
Stink bug	2	3.1
Spider	2	3.1
Honey bee	2	3.1
Caterpillar*	2	3.1
Fruit fly*	1	1.5
Cat*	1	1.5
Gnat*	1	1.5
Butterfly*	1	1.5
Worm*	1	1.5
Snail*	1	1.5
Toad	1	1.5
Monkey	1	1.5
Praying mantis	1	1.5
Wasp	1	1.5

*Not included in the pile sort.

Table 5-3. Ethnographic taxonomy of 33 pests (frequency and percent of responses, N=65). The scientific common name is underlined, and the Barbadian common name is listed under the scientific common name.

Specimen	Frequency	Percent	Recognized, but could not name	Incorrectly named
<u>Gecko</u>	<u>65</u>	<u>100.0</u>	<u>0</u>	<u>0</u>
House lizard	23	35.4	-	-
Gecko	22	33.8	-	-
Poison lizard	9	13.8	-	-
White lizard	6	9.2	-	-
Night lizard	1	1.5	-	-
Ground lizard	1	1.5	-	-
Slav	1	1.5	-	-
Cold lizard	1	1.5	-	-
Lizard	1	1.5	-	-
<u>Whistling frog</u>	<u>65</u>	<u>100.0</u>	<u>0</u>	<u>0</u>
Frog	40	61.5	-	-
Tadpole	16	24.6	-	-
Toad	6	9.2	-	-
Crapo	2	3.1	-	-
Jumping frog	1	1.5	-	-
<u>Large cockroach (Periplaneta spp.)</u>	<u>65</u>	<u>100.0</u>	<u>0</u>	<u>0</u>
Cockroach	64	98.5	-	-
Mahogany bird	1	1.5	-	-
<u>Honey bee</u>	<u>65</u>	<u>100.0</u>	<u>0</u>	<u>0</u>
Honey bee	65	100.0	-	-
<u>Large centipede</u>	<u>65</u>	<u>100.0</u>	<u>0</u>	<u>0</u>
Large centipede	65	100.0	-	-
<u>Lizard</u>	<u>65</u>	<u>100.0</u>	<u>0</u>	<u>0</u>
Lizard	65	100.0	-	-
<u>Fly</u>	<u>65</u>	<u>100.0</u>	<u>0</u>	<u>0</u>
Fly	65	100.0	-	-

Table 5-3 -- continued.

Specimen	Frequency	Percent	Recognized, but could not name	Incorrectly named
<u>Mouse</u>	<u>64</u>	<u>98.5</u>	<u>1 (1.5)</u>	<u>0</u>
Mouse	64	98.5	-	-
<u>Millipede</u>	<u>64</u>	<u>98.5</u>	<u>0</u>	<u>1 (1.5)</u>
Millipede	62	95.4	-	-
Hard-back Harry	2	3.1	-	-
<u>Spider</u>	<u>62</u>	<u>95.4</u>	<u>1 (1.5)</u>	<u>0</u>
Spider	62	95.4	-	-
<u>Ant (small)</u>	<u>61</u>	<u>93.8</u>	<u>0</u>	<u>2 (3.1)</u>
Ant	53	81.5	-	-
Sweet/sugar ant	3	4.6	-	-
Running ant	2	3.1	-	-
Biting ant	2	3.1	-	-
Crazy ant	1	1.5	-	-
<u>Stink Bug</u>	<u>61</u>	<u>93.8</u>	<u>2 (3.1)</u>	<u>2 (3.1)</u>
Pea chink	58	89.2	-	-
Green bug	1	1.5	-	-
Bush bug	1	1.5	-	-
Pea lice	1	1.5	-	-
<u>Ant (large)</u>	<u>61</u>	<u>93.8</u>	<u>0</u>	<u>3 (4.6)</u>
Ant	41	63.1	-	-
Big-head ant	12	18.5	-	-
Wood ant	4	6.2	-	-
Biting ant	2	3.1	-	-
Sugar ant	1	1.5	-	-
Smelling ant	1	1.5	-	-
<u>Slug</u>	<u>60</u>	<u>95.2</u>	<u>0</u>	<u>1 (1.5)</u>
Slug	60	95.2	-	-

Table 5-3 -- continued.

Specimen	Frequency	Percent	Recognized, but could not name	Incorrectly named
Bat	59	90.8	2 (3.1)	3 (4.6)
Bat	52	80.0		
Mouse bat	3	4.6	-	-
Duppy bat	2	3.1	-	-
Night bat	2	3.1	-	-
Ladybug/Ladybird	58	89.2	1 (1.5)	5 (7.7)
Ladybug/Ladybird	58	89.2	-	-
Mosquito	58	89.2	0	2 (3.1)
Mosquito	58	89.2	-	-
"Giant" (Blaberus spp.) cockroach	58	89.2	0	2 (3.1)
Giant	38	58.5	-	-
Knocker	11	16.9	-	-
Giant mahogany bird	4	6.2	-	-
Cockle	3	4.6	-	-
Hard-back cockroach	2	3.1	-	-
Small centipede	57	87.7	1 (1.5)	5 (7.7)
Centipede	56	86.2	-	-
Christmas worm	1	1.5	-	-
Termite	57	87.7	0	7 (10.8)
Rain fly/ant	21	32.3	-	-
Flying ant	14	21.5	-	-
Wood ant	11	16.9	-	-
Termite	10	15.4	-	-
Wood eater	1	1.5	-	-
Rat	56	86.2	0	9 (13.8)
Rat	56	86.2	-	-

Table 5-3 -- continued.

Specimen	Frequency	Percent	Recognized, but could not name	Incorrectly named
Grasshopper	54	83.1	2 (3.1)	7 (10.8)
Grasshopper	54	83.1	-	-
Cricket	54	83.1	2 (3.1)	7 (10.8)
Cricket/Money cricket	54	83.1	-	-
Praying Mantis	41	63.1	13 (20.0)	8 (12.3)
God horse	36	55.4	-	-
Praying mantis	4	6.2	-	-
Wood horse	1	1.5	-	-
German cockroach	39	60.0	1 (1.5)	4 (6.1)
German cockroach	28	43.1	-	-
Johnny Possel	8	12.3	-	-
Different species of an American cockroach	2	3.1	-	-
Jack Spaniard	1	1.5	-	-
Sand fly	33	50.8	3 (4.6)	10 (15.4)
Sand fly	28	43.1	-	-
Sour fly	2	3.1	-	-
Pepper fly	2	3.1	-	-
Pygmy fly	1	1.5	-	-
Mosquito larvae	26	40.0	3 (4.6)	3 (4.6)
Mosquito larvae	24	36.9	-	-
Baby mosquitoes	1	1.5	-	-
Ning-nings	1	1.5	-	-

Table 5-3 -- continued.

Specimen	Frequency	Percent	Recognized, but could not name	Incorrectly named
<u>Sowbug</u>	<u>25</u>	<u>38.5</u>	<u>16 (24.6)</u>	<u>9 (13.8)</u>
Hog lice	20	30.8	-	-
Sowbug	2	3.1	-	-
Pig lice	1	1.5	-	-
Grub	1	1.5	-	-
Mud lice	1	1.5	-	-
<u>Scorpion</u>	<u>22</u>	<u>33.8</u>	<u>1 (1.5)</u>	<u>1 (1.5)</u>
Scorpion	22	33.8	-	-
<u>Moth</u>	<u>18</u>	<u>27.7</u>	<u>1 (1.5)</u>	<u>45 (69.2)</u>
Moth	15	23.1	-	-
Bat	3	4.6	-	-
<u>Fleas</u>	<u>18</u>	<u>27.7</u>	<u>3 (4.6)</u>	<u>16 (24.6)</u>
Fleas	17	26.2	-	-
Chinks	1	1.5	-	-
<u>Tick</u>	<u>16</u>	<u>24.6</u>	<u>3 (4.6)</u>	<u>21 (32.3)</u>
Tick	16	24.6	-	-
<u>Wasp</u>	<u>5</u>	<u>7.7</u>	<u>8 (12.3)</u>	<u>37 (56.9)</u>
Wasp	5	7.7		

All of the informants were able to correctly identify at least seven of the specimens, and for only seven of the 33 total specimens could less than 50% of the informants correctly identify the animal. The less frequently identified pests included mosquito larvae, for which 40% of the informants could identify, a sowbug, recognized by 63.1% of the informants, but correctly named by only 38.5%, a scorpion, recognized by 33.8% (despite its absence on Barbados), fleas, identified by 27.7%, and a tick, identified by 24.6%. The wasp was called a number of different insect names, but only "wasp" by 7.7%. The moth specimen was identified by 27.7% of the informants, but it should be noted that 69.2% (N=45) of the informants called the specimen a butterfly, and this was counted as an incorrect answer.

Ability to correctly name the specimens was not correlated to age, sex, wealth, educational level, or occupational status of the informant. Also, there was no difference in ability to identify the specimens according to residential location.

The harmless gecko was referred to by more colloquial names than any of the other pests, but was correctly identified by all informants, indicating its commonality. It was called "gecko" by only a third of the informants; the remaining names refer to a type of lizard, an understandable assumption. Ants, both small and large, are typically

identified with a variety of adjectives as well, including "sweet," "'running," "biting," "crazy," "smelling," and "big-head." Cockroaches are given a surname (e.g., Johnny Possel, Jack Spaniard), or humorous references (e.g., a "knocker," "mahogany bird," "cockle"). Names for bats connote superstitious beliefs, such as "duppy bat." Bats are sometimes called "moths," and moths are sometimes called "bats." Termites are usually referred to as a type of ant (e.g., "rain," "flying," "wood"), although, upon inquiry, informants note that they are actually a termite, or an insect that damages wood. Only 10.8% of the informants could not identify the termite correctly.

G.A. Forde (1988) has collected and published a number of interesting folk beliefs about different household pests, and almost all of these beliefs were mentioned during the "household pest" section of the questionnaire. Not surprisingly, the relatively benign, accidental household pests possess rather ambivalent beliefs; one cricket, for example, promises to bring money to the house and must not be killed, although another cricket, "which is not as noisy as the first," comes to a home to announce that a family member is going to die (Forde 1988, p.13). Similarly, a <u>green</u> grasshopper flying into the home is bad luck, and the animal should be killed immediately, but a <u>brown</u> grasshopper is good luck and should <u>not</u> be killed (Forde 1988).

Sentiments towards the mongoose in Barbados are bittersweet; people recognize that it is a pest to householders raising fowl, but the animal is considered attractive, and very few of the total population interviewed throughout the year-long study ever attempted to kill a mongoose. One informant--an old man--sat day by day, at his front window in the center of Bridgetown, looking across the street at an old church that was undergoing renovation. When he was asked the question, "what are some of the things you watch for each day?", he replied:

> I watch the mongoose come runnin' out from under de building there. They usually two of 'em. They play and such. I'd love to catch one of 'em...I'd like to have one, an' keep it as a pet. I'd just like to have it to admire it...

According to Forde (1988), legend says that, if a mongoose runs across the road in front of one, it is a sign of good luck (the antithesis of a black cat running in front of a person and bringing bad luck).

A fascinating colloquial name, and one for which none of the informants could explain to the author its origin, was the "godhorse." A godhorse is, according to Forde (1988), a walking stick, although informants referred to the praying mantis in the pile sort as a godhorse. Yet even Forde recognizes that the two are often confused (1988). Forde believes that the name "godhorse" is African in origin, noting that in South Africa the praying mantis (not

the walking stick) is referred to as the "Hottentot god"; he therefore speculates that "the name godhorse was originally brought from Africa and given to the mantis, and because many people confuse the two insects, the name was eventually transferred to the stick insect" (Forde 1988, p.17).

Not surprisingly, beliefs regarding the centipede are contemptuous; seeing a centipede crossing one's path indicates that the individual has an enemy, and the centipede should therefore be killed immediately (Forde 1988). The centipede is literally the most dangerous animal on Barbados in regard to a painful bite--there are no snakes, dangerous spiders or otherwise potentially lethal animals--yet even the centipede bite is far from fatal. Nevertheless, belief about the seriousness of a centipede bite is represented in the aggressive folk belief about the animal.

After naming each of the specimens, and teaching the client the actual name of each specimen in the event that she/he did not already know the name, the client was asked to choose, from the collection, the pest with which she/he had the biggest problem in her/his home. The first four pests--and the only ones for which at least 10% or more of the informants cited that pest as the "biggest problem" pest--were the same pests, in almost the same order, as those from the free listing: <u>Periplaneta</u> cockroach, mouse, mosquito, and fly (Table 5-4). Interestingly, notoriously

harmless "pests" (lizard, gecko, and toad) were included in the "biggest problem" list. One informant chose the house dust mite card as her "biggest problem" pest, a choice that no doubt reflects the fact that she was the parent of an asthmatic child. Table 5-4 presents the frequencies and percentages of the selected "biggest problem" pests.

Table 5-4. Frequency and percentage of responses to the question: "which pest do you have the biggest problem with?" (N=65).

Pest	Frequency	Percent
Cockroach (<u>Periplaneta spp.</u>)	14	21.5
Mouse	13	20.0
Mosquito	8	12.3
Fly	8	12.3
Sand fly	5	7.7
Millipede	5	7.7
Rat	4	6.2
Cockroach, German	2	3.1
Lizard	2	3.1
Gecko	1	1.5
Ant	1	1.5
House dust mite	1	1.5
Toad	1	1.5
Total	65	100.0

<u>Reported Temporal Distributions</u>

Clients were asked to select those specimens and cards that they had ever seen around their home. They were asked to place the specimen/card under one of five categories, including the following: 1) usually/always see; 2) see once a month; 3) see during the rainy season only; 4) rarely see;and 5) never see. Table 5-5 illustrates the frequency

Table 5-5. Frequency and percent of specimen categorization regarding when informant sees the animal around the house (N=65).

Pest	Usually/always see around the house	See once a month	See during the rainy season only	Rarely see	Never see
Fly	54 (83.1)	5 (7.7)	4 (6.2)	2 (3.1)	0
Lizard	53 (81.5)	4 (6.2)	0	8 (12.3)	0
Ant, small	51 (78.5)	3 (4.6)	4 (6.2)	6 (9.2)	1 (1.5)
Cockroach (_Periplaneta_)	49 (75.4)	9 (13.8)	5 (7.7)	2 (3.1)	0
Mosquito	46 (70.8)	2 (3.1)	11 (16.9)	5 (7.7)	1 (1.5)
Gecko	40 (62.5)	11(17.2)	-	9 (14.1)	4 (6.2)
Millipede	39 (60.0)	4 (6.2)	12 (18.5)	7 (10.8)	3 (4.6)
Sand fly	32 (50.8)	3 (4.8)	12 (19.0)	12 (18.5)	4 (6.3)
Mouse	31 (47.7)	6 (9.2)	-	26 (40.0)	2 (3.1)
Moth	29 (44.6)	11(16.9)	1 (1.5)	16 (24.6)	8 (12.3)
Honey bee	28 (43.1)	7 (10.8)	-	28 (43.1)	2 (3.1)
Spider	28 (43.1)	11(17.2)	1 (1.6)	22 (34.4)	2 (3.1)
Whistling frog	25 (38.5)	4 (6.2)	25 (38.5)	8 (12.3)	3 (4.6)
Ant, large	25 (38.5)	7 (10.8)	11 (16.9)	15 (23.1)	7 (10.8)
Mongoose	21 (32.3)	6 (9.2)	0	13 (20.0)	25 (38.5)
Toad	21 (32.3)	3 (4.6)	22 (33.8)	9 (13.8)	10 (15.4)
Giant cockroach (_Blaberus spp._)	19 (29.2)	7 (10.8)	3 (4.6)	14 (21.5)	22 (33.8)
Cricket	16 (24.6)	10(15.4)	6 (9.2)	21 (32.3)	12 (18.5)
Grasshopper	14 (21.5)	12(18.5)	6 (9.2)	29 (44.6)	4 (6.2)
Rat	13 (20.3)	6 (9.4)	0	25 (39.1)	20 (31.3)
Slug	12 (18.5)	5 (7.7)	32 (49.2)	10 (15.4)	6 (9.2)
Bat	12 (18.5)	3 (4.6)	2 (3.1)	22 (33.8)	26 (40.0)
Ladybug/ladybird	11 (16.9)	13(20.0)	2 (3.1)	32 (49.2)	7 (10.8)
Centipede, small	11 (16.9)	3 (4.7)	6 (9.4)	31 (48.4)	13 (20.3)
German cockroach	10 (15.4)	5 (7.7)	-	14 (21.5)	36 (55.4)
Centipede, large	10 (15.4)	4 (6.2)	9 (13.8)	34 (52.3)	8 (12.3)

Table 5-5 -- continued.

Pest	Usually/always see around the house	See once a month	See during the rainy season only	Rarely see	Never see
Stink bug	8 (12.3)	12(18.5)	0	38 (58.5)	7 (10.8)
Flea	8 (12.3)	5 (7.7)	0	20 (30.8)	32 (49.2)
House dust mite[a]	7 (10.8)	5 (7.7)	1 (1.5)	5 (7.7)	47 (72.3)
Monkey	7 (10.8)	8 (12.3)	0	20 (30.8)	30 (46.2)
Termite	6 (9.2)	8 (12.3)	46 (70.8)	4 (6.2)	1 (1.5)
Sowbug	6 (9.2)	6 (9.2)	6 (9.2)	21 (32.3)	26 (40.0)
Wasp	4 (6.2)	9 (13.8)	1 (1.5)	22 (33.8)	29 (44.6)
Praying mantis	3 (4.6)	7 (10.8)	3 (4.6)	37 (56.9)	15 (23.1)
Tick	3 (4.6)	7 (10.8)	0	16 (24.6)	39 (60.0)
Mosquito larvae	3 (4.7)	4 (6.2)	15 (23.4)	19 (29.7)	23 (35.9)
Scorpion[b]	0	0	4 (6.2)	61 (93.8)	

[a]House dust mites are microscopic and cannot be seen with the unaided eye.
[b]There are no species of scorpions inhabiting Barbados.

with which the specimens were reportedly seen around the home.

All of the pests in the pile sort had been sighted by at least one informant; the least-reported pest was the scorpion, in which four persons stated that they saw the scorpion "rarely." This is interesting given that no species of scorpions exist on Barbados, but the fact that it was the least reported pest suggests a high degree of reliability of the pile sort tool.

Eight of the total 37 pests free-listed at the start of the interview, and seven of the thirteen pests selected from the pile sort as "the biggest problem" pests, were "usually/always" seen around the home by more than 50% of the informant population. Cockroaches (Periplaneta spp.) headed the free-list and the "biggest problem" list and were reported by more than 75% of the informants as "usually/always seen" around the home, deeming cockroaches as possibly the most common household pest in Barbados. A list of the most common pests based on free listing, choosing from the pile sort the "biggest problem" pest, and those "usually/always" reported around the home by 47.7% or more of the informants (in order to include "mouse"), is as follows: 1) cockroach (Periplaneta spp.); 2) fly; 3) mouse; 4) mosquito; 5) millipede; 6) lizard; 7) gecko; and 8) ant. Rats were not commonly seen around the home--70.4% of the informants rarely or never saw them around their home--but

are a pest of great concern, free-listed by 38.5% and a "biggest problem" pest to 6.2% in the study. Although moths were only free-listed by four informants, and not chosen as a "biggest problem" pest, they were usually/always seen around 44.6% of the informants home, and are of great allergenic concern. Sand flies and German cockroaches were not an overall problem, but of great concern to some informants, and also important allergenically. Termites were free-listed, but were not considered a "biggest problem" pest, and are important to 70.8% of the population only during the rainy season. However, the characteristic "swarm" flight patterns of termites as described in the initial section of this chapter suggest that they too may be of great allergenic importance; therefore, it was considered prudent to include termites in an investigation of sociodemographic and structural relationships. It should be mentioned that geckos are of allergenic concern because of their habit of leaving numerous fecal pellets stuck to walls, counters, and ceilings--any place where the animal has visited. These pellets, over time, become dried and aerosolized, and are therefore potential aeroallergens.

The result is a list of 13 pests that are both common and of great concern to the sample population and/or of concern from an immunological point of view in regard to their allergenicity and predominance.

Interrelationships with Sociodemographic and Structural Variables

Upon correlating the frequency of sighting the 13 pests of interest with specific sociodemographic and structural variables, no statistical differences were found in responses regarding classification of the informant (parent/guardian of an asthmatic or non-asthmatic child), age, sex and educational level of the informant. However, a number of pest-specific correlations were found.

Rodents

A definite relationship between poor quality homes and the presence of rodents was evident in the sample population. Frequent sightings of rats were positively correlated to living in a wood home (t=2.17; df=33.0, equal variance, p=0.04), living in a home with a simple rock foundation (f=4.21; df=4, 59; p=0.005), having less of a finished ceiling (f=2.92; df=7, 56; p=0.01), and living in the rural sector (t=1.96; df=62.0, equal variance, p=0.05). Informants of lower status occupations or currently unemployed reported seeing rats more frequently than their higher status job counterparts (f=5.50; df=3, 60; p=0.002).

Frequent sightings of mice were not related to most of the same variables as rats. Mice infestations were not limited to the rural environment; there was no difference between urban and rural residency and frequent sightings of mice, nor was there a relationship between the construction of the home and seeing mice. Frequent sightings of mice was

inversely related to the degree of wealth; sightings were most often reported from the poorer informants ($f=2.99$; $df=3, 61$; $p=0.04$) and persons in occupations of lower status ($f=3.41$; $df=3, 61$; $p=0.02$).

The relationship between rats and poorer quality homes probably is due to the openness of these domestic environments, thus allowing easy access in and out of the home during the animal's search for food. The relationship between poverty and poor upkeep of surrounding environs--thus additional food sources of garbage and water collection--cannot be discounted. The findings suggest that there is an <u>inverse</u> relationship between modernization of the domestic environment and exposure to rodents, which minimizes the likelihood of developing allergies to these pests and is certainly favorable in overall health.

<u>Cockroaches</u>

The presence of <u>Periplaneta</u> spp. cockroaches around the home was not correlated to any of the sociodemographic or structural variables. This is perhaps because the presence of this species in the home was so pervasive in the overall sample. One possible explanation as to why there were no observable relationships is the overall moisture level; namely, water is the most important constraining factor in cockroach survival, and it is likely that the relative humidity level in the macroenvironment supersedes the importance of the microenvironment. As a result,

Periplaneta spp. infestations are everyone's problem in Barbados and are not limited to specific house types. The presence of German cockroaches (Blattella germanica) was correlated to several of the variables. German cockroaches were significantly more of a problem in the urban sector than in the rural sector ($t=2.0$; $df=63.0$, equal variance, $p=0.05$), especially in the densely populated regions ($f=3.51$; $df=3, 61$; $p=0.02$). "Wealth," according to amenities, was not correlated to German cockroach sightings, but having an occupation of low status or no occupation ($f=2.94$; $df=3, 61$; $p=0.04$) and not owning one's house spot ($t=2.45$; $df=61.4$, unequal variance, $p=0.02$) was correlated to frequent German cockroach sightings. Also, living in a home with fewer windows ($f=2.61$; $df=3, 61$; $p=0.06$) was related to high numbers of German cockroaches.

In temperate climes, the German cockroach is typically found in crowded living conditions, especially in the urban sector. Its propensity for a similar environment in Barbados is not surprising. Although German cockroaches are believed to be more of a commercial than a domestic problem, it is important to note that in the particularly dense urban sector, shops and groceries are often nestled within urban villages; thus, there is little distance for the cargo-infesting German cockroach to travel when in search of a new habitat. More sightings in homes with fewer windows may represent the insect's preference for a microhabitat with

minimal ventilation and light. This difference in distribution between _Periplaneta_ spp. and the German cockroach is probably due in part to ecological differences between the two species. _Periplaneta_ spp. are less dependent on human-made, indoor environs than is _Blattella germanica_.

Mosquitoes

"Usually/always" seeing mosquitoes was related to several of the German cockroach correlations. Mosquitoes were a greater problem for informants living in the urban sector ($t=3.64$; $df=35.7$, unequal variance, $p<0.001$), especially in the densely urban regions ($f=5.24$; $df=4, 60$; $p=0.001$). While structural features of the home were not correlated to mosquito sightings, not owning one's house ($t=2.80$; $df=47.7$, unequal variance, $p=0.007$) or the house spot ($t=2.40$; $df=63.0$, equal variance, $p=0.02$) were significant factors. These correlations suggest a relationship between available breeding sites and the sociodemographic variables. The most densely urban sector is one in which sewerage disposal is sometimes inefficient; in downtown Bridgetown it is not uncommon to see waste water drained outside the front of the house onto the street gutters. Also, as has been presented, more of the densely urban proportion of the population live on rented land, thereby limiting the number of indoor water taps and necessitating the storage of water in large buckets--a

possible breeding site for mosquitoes. Furthermore, urban poverty is characterized by poor peridomestic upkeep and the presence of discarded, human-made articles that serve as potential breeding sites for mosquitoes (e.g., tires, bottles, tin cans). Another explanation for the greater frequency in the urban region is the geophysical situation of the urban sector; the leeward side of the island has a significantly lower wind velocity than the windward coast (rural district), where flight of both mosquitoes and sand flies is disrupted (personal observation).

Although the correlations indicate that seeing mosquitoes frequently is more of a problem for urbanites in rented housing, the overall frequency with which informants included mosquitoes as a common pest, and their pervasiveness throughout the island, suggests that they may be a common source of allergy nonetheless.

<u>Sand flies</u>

Frequent sightings of sand flies--or more credibly, frequent <u>bites</u> from sand flies, because they are difficult to spot--were related to several sociodemographic and structural variables. Informants in poorer quality homes complained more about sand flies than did informants in better quality homes. Frequent sightings of sand flies was reported more by informants with lower amenities scores ($f=3.14$; $df=2, 62$; $p=0.05$) and by those who rented the house spot ($X^2=65.0$; 2 df, $p<0.001$). Sightings were also

correlated to houses with fewer rooms (f=4.11; df=2, 62; p=0.02). One explanation for the association of sand flies and poorer homes is the relative openness of the poorer homes, with greater access to the indoors, and subsequently greater access to the human host. The same can be postulated for the mosquito. While the better-built homes in Barbados are, overall, largely open to the outdoors by developed country standards, they may be more efficient than the poorer homes in terms of effectiveness of household insecticides (sprayed in a relatively confined environ), which are relied upon heavily throughout the population.

<u>Others</u>

Frequent sightings of flies were not correlated to any of the variables, illustrating the pervasiveness of flies throughout the island. The same was found with moths, ants, millipedes, and lizards, possibly for the same reason. Similarly, sightings of termites were not correlated to any of the variables. The fact that sightings of termites was not associated with timber homes is not surprising, because they are likely to be as serious a problem in mixed (wood and concrete) dwellings as all-wood dwellings.

Frequent sightings of geckos was correlated to having poorer foundations (f=4.01; df=3, 60; p=0.01) in the home, but was not related to any of the other variables. It is difficult to interpret the meaning of these associations, as geckos are common in all homes; they feed on insects

attracted to artificial lights after sunset. Perhaps the greater openness in the poorer homes allows for greater numbers of flying insects and subsequently, the attraction of a greater food supply for geckos.

Nearly three-quarters of the sample population (72.3%) stated that they never "saw" house dust mites. This means that over 25% of the informants cited the presence of a pest in their home that can not be seen with the naked eye, and one in which there has been virtually no quantification or qualification in Barbados in general, much less at the individual household level. More informants in the urban sector believed they had house dust mites more frequently than rural residents, at the 0.10 level ($t=1.94$; $df=63.0$, unequal variance, $p=0.06$). There was no association between stated house dust mite infestations and having a child with asthma; in fact, slightly more parents without an asthmatic child (31.3%) reported having house dust mites than did parents with an asthmatic child (26.5%).

The pile sort was useful in distinguishing between the emotional disdain for a pest, versus the belief that a pest was a real problem in the home. For example, selecting the *Periplaneta* cockroach as the biggest pest problem of all the 37 specimens was correlated to seeing the cockroach frequently around the house ($t=3.9$; $df=50.0$, unequal variance, $p<0.001$). Similar correlations were found with the mouse ($t=4.68$; $df=33.4$, unequal variance, $p<0.001$) and

the rat ($t=14.49$; $df=59.0$, unequal variance, $p<0.001$). Previous entomological surveys have found that visual aids (e.g., specimens) are more effective in evaluating knowledge and attitudes regarding household pests; respondents are more likely to recognize an actual arthropod than the name of an arthropod (Thoms 1985).

Classifying the Pests: What's Good and Bad?

Limited data are available that assess the perceptions and attitudes of residents affected by household pests (Wood et al. 1981; Byrne et al. 1984; Zungoli & Robinson 1984; Robinson & Zungoli 1985; Thoms 1985; Thoms & Robinson 1986). Of these, few have identified the impact of "knowledge" on levels of household pest infestations. It may be inferred that, if residents believe an arthropod is dangerous, they will minimize the degree of contact, when possible. Byrne et al. note that, when people have limited knowledge of animals, they tend to be more aware of the ones that can harm humans and notice them more often than favorable animals (e.g., butterflies) (1984). Furthermore, certain sociodemographic variables, such as income, may have more influence over the level of infestation and thus obscure the importance of knowledge as an influencing variable.

From the pile sort of 37 different household pests, informants were asked several questions regarding the classification of each pest. With the collection displayed before the informant, she/he arranged the specimens into two

different piles, depending on the question. Informants were asked these questions to determine how they viewed the various species--as a real threat to humans, or not. The rationale for assessing informant categorization and classification of pests on this level was the following: Does the perception of an animal as potentially harmful to people and their families enhance awareness of that animal's presence, and, are efforts at prevention or eradication of that animal's presence heightened in the event that the animal is perceived as harmful? The following paragraphs present the results of the pile sorting.

Which of these are "disgusting"?

Recognizing that the word "disgusting" may connote different meanings to different people, this question was elaborated when presented to the informant. Informants were asked to choose the pests that they did not like to see, that repulsed them, or gave them a bad feeling. In no case did there appear to be any hesitation by the informant to qualify this term.

Table 5-6 illustrates the informants' selection of disgusting pests. There was no difference in the total number of pests classified as "disgusting" according to age, sex, residential region, or wealth. Once again, the Periplaneta cockroach, mouse, millipede, and fly head the list. Although informants did not report seeing large centipedes frequently, the arthropod evoked a sense of

repulsion by 60% of the sample, preceded only by the Periplaneta cockroach, rat, and mouse. The same was true of the Blaberus cockroach, which ranked seventeenth in frequency of sightings, but was the sixth most disgusting specimen (58.5% of the sample), and the slug, which ranked 21 on the frequency list, but was eighth on the "disgusting" list (49.2%). Conversely, frequently seen pests such as the gecko, and especially the moth and spider, were not particularly disgusting animals according to the informants; although moths were the tenth insect usually seen around the house, they ranked thirty-second as the most disgusting pest, and spiders, the twelfth most frequently seen pest, ranked thirty-fourth as the most disgusting pest.

Which of these are "harmful"?

The two pests that are believed to be largely responsible for leptospirosis headed the list of pests "most harmful" to humans and were the rat (83.1%) and mouse (80%) (see Table 5-7). In fact, leptospirosis was the most frequently cited illness caused by any of the specimens. Although leptospirosis actually affects a relatively small proportion of the entire population (an average of 17.6 cases per year), response to this particular question illustrates the exceptional success that national campaigning has had on educating the public. It also demonstrates that, despite a relatively low frequency of rats in the home, and a relatively high frequency of mice in

the home, informants are acutely aware of exactly what diseases are spread by rodents. Despite a void of information regarding leptospirosis in mice, this animal is classified almost the same as the rat in the Bajan worldview.

Similar applications of disease were made for two of the cockroaches; the Blaberus cockroach, a species that was not particularly common in the home, was classified as harmful in the same manner as the Periplaneta cockroach (contamination, biting, eliciting fever and infection, urinating on personal items, and causing "fright"). Oddly, it ranked ahead of Periplaneta in degree of harmfulness (72.3% versus 58.5%). This is surprising given Blaberus' extreme rarity in comparison with Periplaneta. The German cockroach was perceived as harmful by a smaller proportion of the population (20%), but again, was regarded as harmful in the same manner as the other two cockroaches.

In conclusion, there was not a significant relationship between perceived degree of harmfulness and density and/or frequency of pest populations. Rats, mice, Blaberus cockroaches, and large centipedes, were regarded as particularly dangerous animals, despite their low frequency in the home, while flies, mosquitoes, and millipedes were only believed to be harmful by 52.3%, 44.6%, and 37.0%, respectively, and yet these pests were more frequently sighted in the home than the former. Furthermore, the

second most-commonly sighted pest, the lizard, was not reported to be harmful to humans by any of the informants. This point suggests that the hypothesis proposed by Byrne et al. (1984) may not be applicable to the Barbadian population, in general, because residents did fairly well at distinguishing between commonly-seen pests and harmful pests.

The intense focus on the Blaberus cockroach, despite its probable rarity in Barbadian homes, is reflective of other studies regarding attitudes and fear toward certain animals. Bennett-Levy and Marteau, in an analysis on the "perceptual characteristics" of animals that are important in determining their appraisal by humans (positive or negative), found that "ugly, slimy, speedy or sudden-moving animals" are more fear-provoking than animals that do not share these qualities (1984, p.40). They suggested that intensity of fear and apparent irrationality was not only determined by perceived harmfulness of the animal, but also by perceptual characteristics, to the degree that the animal was physically different from humans, or the "mammalian form" (Bennett-Levy & Marteau 1984). Cockroaches tend to fair poorly when compared to other animals in public preference studies (Kellert 1980), so it is no surprise that a very large cockroach elicits such a degree of aversion as the Blaberus did in the asthma study. A similar explanation could be argued for responses to the large centipede,

because the smaller species are much more common in and around homes that the large one. In short, larger animals (e.g., Blaberus cockroaches, large centipedes, rats) appear to evoke the greatest fear.

Which of these pests would you kill?

Table 5-8 illustrates the frequencies and proportion of the sample population that would kill one of the pests if they saw it. Note that all of the pests were listed by at least 10% of the sample, indicating that even though a pest is not perceived as harmful, an individual may want to eliminate the pest anyway. Almost the same pests most frequently listed as causing harm to humans were the most frequently listed as those that informants would kill, including rats, Periplaneta and Blaberus cockroaches, mice, and the large centipede. Nevertheless, pests perceived as harmless, including the spider and lizard, would be killed by more than 25% of the population.

Oddly, the Barbados study indicated that general dislike for an animal results in a greater likelihood of wanting to kill it than does the perception of that animal as harmful. More correlations were found between the degree of disgust for an animal and wanting to kill it, than the perception of an animal as harmful and wanting to kill it. This suggests an irrational fear or overall negative perception over many common household pests, a phenomenon that is well-described in the literature (Levenson & Frankie

1983; Byrne et al. 1984; Thoms & Robinson 1986; Hahn & Ascerno 1991). In a more general sense, those pests that elicit a high degree of disgust are the pests that an informant is likely to kill on sight; the inverse is true as well, in that pests that do not elicit a response of disgust are much less likely to be killed by that person. Table 5-9 illustrates the numerous correlations between disliking an animal and wanting to kill it.

Which of these are "beneficial"?

Only 15 of the 37 pests were regarded as "beneficial" by the sample population, and only four animals were considered beneficial by more than 10% of the population; the highest percent was only for 26.2% of the population (gecko). Perceptions were very reflective of what is scientifically true; perhaps two of the most beneficial animals in the pile sort were most frequently recognized as beneficial--the gecko and lizard. The honey bee was highly appreciated also, despite the perception that it is harmful; this reflects the fact that honey production is a substantial business in Barbados. Two relatively favorable pests were selected based on aesthetic merits--the moth and ladybug. There were several oddities regarding "beneficial" pests, which are not entomologically sound arguments, but beliefs that were represented by one respondent each; one person thought that slugs eat ants, another believed that large ants could ward off termites, and one woman stated

that she raised mosquito larvae to feed to her tropical fish. Despite their widespread distribution and daily visibility in Barbados, bats and whistling frogs are under-reported both in frequency around the home and were not mentioned at all as beneficial animals. Also, the wasp in the collection was the a harmless species that parasitizes cockroach eggs (Evania appendigaster) and is quite common in Barbados; however, it was not considered beneficial to any of the informants.[26] Table 5-10 illustrates the frequencies and proportions of responses.

The total number of pests recognized as "beneficial" was not correlated to age, sex, or residential region, but it was correlated to the degree of wealth; wealthier informants classified more pests as beneficial than did the poorer informants ($r=0.31$, $p=0.01$). In the United States, researchers have found correlations between favorable attitudes toward arthropods and educational level (certainly an index of socioeconomic status in the U.S.) (Byrne et al. 1984; Hahn & Ascerno 1991). This may be explained by the fact that better educated people are more likely to have received information regarding the role of certain animals in the ecosystem. Information supplied to people regarding the beneficial role of an animal, despite the initial perception of that animal, changes in a positive direction once they are aware of it (Thoms 1985; Thoms & Robinson 1986).

Are these pests indoor, outdoor, or accidental?

Periplaneta cockroaches were regarded as indoor (food and garbage) pests more frequently than any of the other specimens, by 84.6% of the informants. Nine people (13.8%), however, believed that they were accidental pests. Flies were the second most-common indoor pest, at 61.5%, followed by the mouse and, strangely, the *Blaberus* cockroach (actually a peridomestic or even a feral species), at 53.8%. Despite their omnipresence throughout Barbadian homes, geckos were classified as "accidental" pests by 98.5% of the population. None of the informants classified house dust mites as an indoor pest. In short, regardless of the frequency with which a pest is found indoors, if it is not perceived negatively, it appears to fall under the category of "accidental" (e.g., the gecko).

Table 5-6. Responses (frequency distribution and percentages) to the question: "Which of these pests do you consider to be 'disgusting'?"

Pest	Frequency	Percent
Cockroach, (*Periplaneta spp.*)	49	75.4
Rat	46	70.8
Mouse	44	67.7
Centipede, large	43	66.2
Millipede	39	60.0
"Giant" cockroach, (*Blaberus spp.*)	38	58.5
Fly	37	56.9
Slug	32	49.2
Mosquito	30	46.2
Centipede, small	28	43.1
Sand fly	25	38.5
Bat	24	36.9
German cockroach	24	36.9
Gecko	23	35.4
Ant, small	21	32.3
Cricket	20	30.8
Lizard	20	30.8
Ant, large	20	30.8
Honey bee	18	27.7
Termite	18	27.7
Stink bug	18	27.7
Grasshopper	16	24.6
Praying mantis	16	24.6
Toad	16	24.6
Flea	15	23.1
Mongoose	15	23.1
Scorpion	14	21.5
Wasp	14	21.5
Tick	14	21.5
Mosquito larvae	13	20.0
Sowbug	13	20.0
Moth	13	20.0
House dust mites	13	20.0
Spider	17	26.2
Ladybug	11	16.9
Monkey	9	13.8

Table 5-7. Responses (frequency distribution and percentages) to the question: "Which of these pests can cause physical harm to people, and how?" (N=65).

Pest	Frequency	Percent
Rat	54	83.1
Leptospirosis	43	66.2
Contaminates food/ utensils/spreads germs	10	15.4
Poisons	1	1.5
Mouse	52	80.0
Leptospirosis	41	63.1
Contaminates food/ utensils/spreads germs	11	16.9
"Giant" Cockroach (Blaberus spp.)	47	72.3
Contaminates food/ utensils/spreads germs	11	16.9
Bite	3	4.6
Fever/infection	1	1.5
Urinates on clothing/ sick from smell	1	1.5
Fright	1	1.5
Can't specify	1	1.5
Cockroach (Periplaneta spp.)	38	58.5
Contaminates food/ utensils/spreads germs	29	44.6
Bite	5	7.7
Fever/infection	1	1.5
Urinates on clothing/ sick from smell	1	1.5
Fright	1	1.5
Can't specify		
Centipede, large	37	56.9
Bite	13	20.0
Causes swelling/welt	8	12.3
Dangerous sting	7	10.8
Fever/infection	4	6.2
Poison	4	6.2
Can't specify	1	1.5
Fly	34	52.3
Contaminates food/ utensils/spreads germs	28	43.1
Dysentery/diarrhea	3	4.6
Fever/infection	2	3.1
Sneezing/wheezing	1	1.5

Table 5-7 -- continued.

Pest	Frequency	Percent
<u>Mosquito</u>	<u>29</u>	<u>44.6</u>
Dengue/malaria	21	32.3
Causes swelling/welt	2	3.1
Marks on skin from scratching	2	3.1
Allergic reaction	1	1.5
Contaminates food/ utensils/spreads germs	1	1.5
Bite	1	1.5
Marks on skin from Fever/infection	1	1.5
<u>Millipede</u>	<u>28</u>	<u>37.0</u>
Poison	14	21.5
Bite	6	9.2
Cause swelling/welt	4	6.2
Contaminates food/ utensils/spreads germs	4	6.2
Fever/infection	3	4.6
Dangerous sting	2	3.1
Exudes cyanide	1	1.5
Kills you by injecting bad blood into you	1	1.5
Leaves a mark/scar	1	1.5
Can't specify	1	1.5
<u>Honeybee</u>	<u>24</u>	<u>36.9</u>
Dangerous sting	17	26.2
Allergic reaction	4	6.2
Causes swelling/welt	2	3.1
Fever/infection	1	1.5
<u>Centipede, small</u>	<u>16</u>	<u>24.6</u>
Causes swelling/welt	4	6.2
Bite	4	6.2
Fever/infection	4	6.2
Dangerous sting	3	4.6
Poison	1	1.5
<u>German cockroach</u>	<u>13</u>	<u>20.0</u>
Contaminates food/ utensils/spreads germs	7	10.8
Bite	3	4.6
Fever/infection	1	1.5
Urinates on clothing/ get sick from the smell	1	1.5
Can't specify	1	1.5

Table 5-7 -- continued.

Pest	Frequency	Percent
Scorpion	11	16.9
Dangerous sting	4	6.2
Bite	4	6.2
Fever/infection	1	1.5
Poisons	1	1.5
Can't specify	1	1.5
Praying mantis	10	15.4
Gets in your ear	10	15.4
Ant, large	8	12.3
Contaminates food/ utensils/spreads germs	3	4.6
Bites	2	3.1
Dangerous sting	1	1.5
Causes swelling/welt	1	1.5
Poison	1	1.5
Bat	7	10.8
Leptospirosis	2	3.1
Rabies	2	3.1
Bite	1	1.5
Poke out your eye	1	1.5
Causes a heart attack	1	1.5
Ant, small	7	10.8
Contaminates food/ utensils/spreads germs	3	4.6
Dangerous sting	1	1.5
Causes swelling/welt	1	1.5
Bite	1	1.5
Fever/infection	1	1.5
Slug	3	4.6
Can't specify	2	3.1
Allergic reaction	1	1.5
Flea	2	3.1
Dangerous sting	1	1.5
Bite	1	1.5
Wasp	2	3.1
Dangerous sting	2	3.1
Moth	2	3.1
Allergic reaction	1	1.5
Sneezing/wheezing	1	1.5
Monkey	2	3.1
Contaminates food/ utensils/spreads germs	2	3.1
Sand fly	2	3.1
Marks on skin from scratching	1	1.5
Fever/infection	1	1.5

Table 5-7 -- continued.

Pest	Frequency	Percent
Mosquito larvae	1	1.5
Contaminates food/ utensils/spreads germs	1	1.5
Termite	1	1.5
Smells	1	1.5
Gecko	1	1.5
Poisons	1	1.5
House dust mites	1	1.5
Asthma	1	1.5
Tick	1	1.5
Contaminates food/ utensils/spreads germs	1	1.5
Toad	1	1.5
Hits with a bone in its back that is poisonous	1	1.5

Note: The following pests were not listed as causing illness: Ladybug, spider, stink bug, lizard, grasshopper, whistling frog, sowbug, mongoose, and cricket.

Table 5-8. Responses (frequency distribution and percentages) to the question: "Which of these pests would you kill if you saw it?" (N=65).

Pest	Frequency	Percent
Centipede, large	56	86.2
Periplaneta cockroach	55	84.6
Mouse	51	78.5
Millipede	42	64.6
Rat	40	61.5
Blaberus cockroach	38	58.5
Centipede, small	38	58.5
Fly	33	50.8
Slug	33	50.8
Mosquito	32	49.2
German cockroach	31	47.7
Honey bee	27	41.5
Scorpion	26	40.0
Fleas	22	33.8
Termite	21	32.3
Ant, large	21	32.3
Whistling frog	21	32.3
Ant, small	21	32.3
Cricket	20	30.8
Wasp	19	29.2
Tick	19	29.2
Sand fly	18	27.7
Praying mantis	18	27.7
Gecko	18	27.7
Stink bug	17	26.2
Lizard	17	26.2
Spider	17	26.2
Mosquito larvae	16	24.6
Bat	16	24.6
Grasshopper	15	23.1
Sowbug	15	23.1
House dust mites	15	23.1
Mongoose	13	20.0
Toad	13	20.0
Moth	12	18.5
Lady bug	10	15.4
Monkey	7	10.8

Table 5-9. Correlations between pests that were classified as "disgusting" and those that the informant "would kill" (Chi-square). A p-value of 0.10 or less was accepted (N=65).

Pest	X^2 value	degrees of freedom	p-value
Blaberus cockroach	15.81	1	<0.001
Whistling frog	10.32	2	0.006
Lizard	8.51	1	0.004
Gecko	7.21	1	0.007
Mosquito	6.78	1	0.009
Millipede	6.46	1	0.01
Bat	5.96	1	0.02
Spider	5.21	1	0.02
Grasshopper	5.11	1	0.02
Fly	4.46	1	0.04
Moth	4.32	1	0.04
Honey bee	3.93	1	0.05
Slug	3.47	1	0.06
Termite	3.56	1	0.06
Centipede, small	3.41	1	0.07
German cockroach	3.34	1	0.07
Cricket	2.75	1	0.10
Praying mantis	2.73	1	0.10

Table 5-10. Responses (frequency distribution and percentages) to the question: "Which of these pests are beneficial, or good to have around?", and "Why?"

Pest	Frequency	Percent
Gecko	17	26.2
Eats other insects	12	18.5
Eats flies	6	9.2
Honey bee	14	21.5
Spreads pollen	8	12.3
Makes honey	6	9.2
Lizard	13	20.0
Eats other insects	9	13.8
Eats flies	6	9.2
Moth	8	12.3
Is attractive/pretty	4	6.2
Pollinates	4	6.2
Toad	4	6.2
Eats flies	3	4.6
Catches other insects	2	3.1
Lady bug	3	4.6
Good for the soil	1	1.5
Eats aphids	1	1.5
Pleasant, & pollinates	1	1.5
Spider	2	3.1
Eats other insects	2	3.1
Millipede	1	1.5
Eats centipedes	1	1.5
Centipede, large	1	1.5
Eats root borers & cockroaches	1	1.5
Slug	1	1.5
Eats ants	1	1.5
Ant, large	1	1.5
Keeps termites away	1	1.5
Ant, small	1	1.5
Fertilizes the ground	1	1.5
Cricket	1	1.5
Brings money/good luck	1	1.5
Monkey	1	1.5
Can be a pet	1	1.5
Mosquito larvae	1	1.5
Can use as fish food	1	1.5

Note that the German cockroach, bat, wasp, mouse, mosquito, tick, praying mantis, rat, scorpion, fleas, stink bug, *Periplaneta* cockroach, *Blaberus* cockroach, small centipede, termite, fly, grasshopper, whistling frog, sowbug, house dust mites, mongoose, and sand fly were not regarded as beneficial.

Behavior Directed at Controlling Household Pests

In addition to understanding how people classify a certain pest (e.g., harmful, accidental), it is important to assess their behavior directed toward that pest, both purposeful (control) and inadvertent (behavior that enhances or dissuades infestations). Such an understanding will assist in designing prevention and control strategies (e.g., minimizing house dust mites in the home), and will serve to target households most at risk for exposure.

National Control

There is heavy reliance on chemicals for control of household pests in Barbados, at all levels--governmental, commercial, and private. A nationalized vector-control program is in effect in Barbados for the control of the aedine mosquitoes, and, in the past, to control for the anopheline species (PAHO 1990). These consist largely--although not exclusively--on ultra-low volume spraying. But as one informant noted:

> There's a real campaign here, especially in the summertime, to contain the water around your house, and not to leave containers that can serve as breeding sites...Most people really try to comply, but in the poor sections of Bridgetown--well, you just can't imagine. People just dump their sewage water right out the front door, sewage draining in the streets, garbage all around the house--it's horrible. Sometimes in the summer you see the trucks with the foggers--I don't know how effective they really are.

Similarly to the building contractors in the private sector, the National Housing Corporation has established a building code that includes chemical treatment against infestation of subterranean termites, of which the providing pest control company must give a warranty for at least 10 years (Babb, personal communication). However, no other pest control service is routinely provided to NHC tenants.

Barbados is fortunate among other Caribbean islands in having a rodent control unit trained by consultants and personnel of the Pan American Health Organization, which is based on the island. Rodent control is managed almost exclusively by the Rodent Control Unit, a division of the Ministry of Health. The unit is comprised of 12 inspection officers, who administer daily inspections in their designated area. An emphasis is placed on public education by the dispersal of literature and verbal explanations in the home via the officers. The primary means of control is poison bait (Active ingredient: 0.0375% coumatetralyl, 226 grams) (Browne, personal communication). In 1990, officers delivered a total of 18,330 packages of bait, mostly in metropolitan Bridgetown, and 24,481 packages were picked up at the Unit by private individuals (Charlie Browne, Rodent Control Unit, personal communication). Persons from the private sector are invited to collect, free of charge, up to two packages at the Unit.

Commercial Control

There are approximately 6 professional pest control companies operating in Barbados (White,[27] personal communication). According to the general manager of Rentokil (Barbados) Limited, contracting business in Barbados is 60% domestic and 40% commercial (Haslett, personal communication). He notes that, although contract business has traditionally been requested by members of the "middle class," people of the lower socioeconomic strata are increasingly requesting commercial services. Haslett remarked on the following:

> Professional pest control is perceived as a status symbol. In England, customers preferred unmarked cars with PCO's [Pest Control Officers] coming to visit them at their home, because professional pest control is embarrassing. In Barbados, marked cars are preferred! They're status symbols!

Professional pest control is comparable to U.S. prices, but, nevertheless, expensive to members of the lower socioeconomic strata. Haslett reports that a contract including initial treatment, plus seven additional treatments throughout the year, would cost an average of $480.00; treatment typically is for cockroaches and/or rodents and excludes flies and mosquitoes (personal communication). Termite treatment is referred to as "job work," or a one-time treatment, totalling 20% of Rentokil's revenue, and 75% of total business (Haslett, Rentokil (Barbados) Limited, personal communication).

Haslett noted that the most common complaints are related to cockroach sightings at night, mostly *Periplaneta* species, in addition to complaints about the German cockroach in both the commercial sector and increasingly in the private sector, and complaints are based on an awareness of health threats due to cockroaches, such as *Salmonella* (personal communication).

Only twenty-four (36.9%) of the study population had ever used professional pest control, and seven (10.9%) stated that they were currently using professional pest control monthly. Most, however, had only received the services one time (62%), and this probably indicates the initial termite treatment on a foundation.

Control in the Private Sector

Perhaps the heaviest use of chemical control for pests in Barbados rests in the hands of the layperson. J.C. Hudson (Carib Agro-Industries Ltd.) laments the increasingly heavy reliance of pesticides and herbicides in the agricultural sector, reporting that as much as 800,000 kilograms of pesticides are imported into Barbados each year (personal communication). He also notes that overuse is not limited to the large plantations, but occurs in backyard gardens as well.

Specifically, over-the-counter insecticides make up a large proportion of insecticide use. There are a number of available brands, varying to some degree in chemical

composition and cost. Companies "sell" their product to West Indians in general by a marketing strategy that emphasizes use for both flying and crawling insects (White, Bayer Caribbean Ltd., personal communication), although, according to Haslett of Rentokil (Barbados) Limited, spray insecticides are purchased mainly for the control of mosquitoes (personal communication). It is difficult to estimate how much is spent in the private sector on over-the-counter insecticides; M. White of Bayer Caribbean Ltd., the maker of "Baygon," the most widely-sold insecticide in the Caribbean, states that each year approximately U.S. $13 million worth of Baygon is sold throughout the Caribbean (personal communication). For Barbados alone, in 1988, wholesale Rentokil insecticide products totaled $1.2 million (Haslett, personal communication). The average cost for a 400 ml can of insecticide ranges from $4.46-$10.14, depending on the brand (personal observation).

The actual number of different pests for which residents said they routinely used an insecticide was relatively small (N=11). However, they include pests for which the sample reported with the greatest frequency, including the <u>Periplaneta</u> cockroach, mosquitoes, flies, and small ants, indicating frequent use of insecticides. When informants were asked how often they bought a can of insecticide, the most frequent answer was "weekly" (40.0%), followed by every two weeks (24.6%). Only 35.4% stated that

they bought a can less than every two weeks. There was no difference in frequency of purchase insecticides according to wealth, the type of home (wood or concrete), or region of residence (urban or rural). Table 5-11 indicates the pests for which insecticides are used and the number of informants who used them.

Table 5-11. Pests for which over-the-counter insecticides are used, by frequency (percent) of the informant population (N=65).

Mosquito	49 (75.4)
Periplaneta cockroach	47 (72.3)
Fly	42 (64.6)
Blaberus cockroach	18 (27.8)
Ant, small	16 (24.6)
German cockroach	10 (15.4)
Stink bug	10 (15.4)
Centipede, small	9 (13.8)
Ant, large	9 (13.8)
Sand fly	8 (8.1)
Millipede	8 (8.1)

Based on ethnographic observations and informant interviews, it can be concluded that the "closing up" of the house (e.g., shutting windows and doors) at the end of the day, or in the morning, after all of the family members have left the home, and spraying an insecticide from room to room, is as common a routine as taking the garbage out to the dump. Informants in all types of homes reported this activity. Ironically, participants in the asthma study were averse to ULV mosquito spraying by the government, "because it smells so bad," that they report shutting "all the windows and doors when we hear the trucks comin' 'round."

Other chemical controls are used that are not aerosols, primarily poison baits for rats and mice (20.0% and 18.5%, respectively), and Sevin powder for millipedes (4.6%), Periplaneta cockroaches (6.2%), large ants (6.2%), small ants (4.6%), and slugs (1.5%). "Slug-It" is another chemical solution used against slugs (3.1%).

Non-chemical, commercial products are used, but primarily against the rodents; sticky traps are used for mice (20.0%) and Periplaneta cockroaches (1.5%), snap traps are used for mice (15.4%) and rats (6.2%), and live traps were reportedly used by one informant (1.5%).

Household products are used on occasion for pest control. Hot water was used to kill millipedes (1.5%), and salt was used to kill slugs (7.7%). Two informants (3.1%) poured kerosene on standing water to kill mosquito larvae. A "shoe" was reportedly used against a mouse, a millipede, cockroaches, and ants. The Sunday Sun newspaper asked people, "How do you feel about cockroaches, and how do you kill them?" (Alleyne 1991). Typical responses included striking the insect with a shoe or a broom; one informant elaborated, "'til their insides ooze out" (Alleyne 1991, p.6A).

Preventive measures for control of household pests were rarely mentioned in the interviews. One informant stated that the family cat was relied upon for controlling mice. Only 1 informant mentioned "keeping things clean" as a form

of prevention of cockroaches; in fact, this was the only case in 65 in which cleanliness was referred to prior to direct questions about cleanliness. Although 18 informants had indicated that they had house dust mites in their home, dusting or cleaning was never mentioned for their control.

When asked directly, informants did admit to storing foodstuff in containers so as to minimize contact with pests. Only 18 informants (27.7%) did not describe a special means for storing their food. Fifty-five percent stored their food in plastic and/or metal containers. Other storage means included the refrigerator, a barrel, or suspending foods from the ceiling.

Structural barriers that were part of the house were never mentioned as means of control. Ethnographic studies and interviews indicate that Bajans are averse to the use of screens in windows, because "they collect dust," or "ya can't stick your head out the window." No association was ever made between keeping fowl pens under or immediately next to house and the frequency of pests such as flies and rats. One of the informants from the entomological survey, living in what was the best quality home in the study, kept fowl pens immediately behind the kitchen, and the greatest number of rats were trapped at that home. However, the householders made no effort whatsoever to eradicate or prevent the rodents.

The Effect of National Campaigns Directed at Community Control

Despite the history of two separate campaigns against two serious pests--the rat and the mosquito--knowledge and behavior related to these two pests is markedly different. Dengue is familiar to most Bajans, but knowledge and appropriate preventative behavior is not. Only two informants had never heard of dengue (3%), although just over 75% were able to correctly identify the pest responsible for dengue; three (5%) informants believed that flies or rodents were involved, and 20% did not know. Most people said that they knew about dengue from the radio (23.1%), television (10.8%), or the multi-media in general (15.4%).

Informants were presented with 11 cards that described actions promoted by health authorities for the control of *Aedes* mosquitoes and therefore dengue. Informants were asked to choose which cards they believed were important for reducing mosquitoes. The maximum proportion of informants who chose any one of the cards was 35.4%, and that was for "placing covers over water containers." Few people believed that emptying catchments, cutting down overgrown vegetation, or disposing bottles, cans, or discarded tires, was important.

Conversely, there is much awareness over the prevention and danger of rats and the disease leptospirosis. All of the informants had heard of leptospirosis, and 93.8% (N=61)

of the informants knew that rats were the main carrier of leptospirosis. Other carriers cited were mice, mosquitoes, frogs, dogs, cats, bats, monkeys, and cockroaches. A number of different answers were given when asked where the informant learned about leptospirosis. Thirty-five percent first heard about leptospirosis from the media, and nearly 17% said they learned about the disease in school. Six of the informants (9.2%) had an acquaintance with the disease.

A number of different responses were given when asked how to control leptospirosis, all of which were applicable to the disease. Most answers dealt with preventing the presence of rodents (84.6%), and the remaining answers dealt with proper sanitation and proper hand-washing.

Summary

Data indicate that the house dust mite, particularly *D. pteronyssinus*, is a serious household pest in Barbados. The intense allergenicity of house dust mites has been presented throughout this thesis, and the implications are that most Barbadian asthmatics probably are subjected to house dust mite allergens. The data also confirm the contention that the modernization process of the domestic environment is resulting in a preferred habitat by the most common house dust mite, and data from previous chapters indicate that this process is a trend and is not likely to be reversed. Specifically, the most important house dust mite species was found in greater quantities in concrete homes and homes in

which moisture-producing features and decreased ventilatory features were incorporated.

Other pests are common in Barbadian homes, although associations between the infestation of these pests and architectural features are less defined. What may be more significant in regards to asthmatics, but was not addressed in this study, is how the structure of the home affects the accumulation and distribution of the allergens of those pests, because their presence is rarely restricted to certain house types and is equally common in different homes.

Other than the use of over-the-counter insecticides on mosquitoes, flies and cockroaches--the most common pests in terms of real numbers--there is little in regard to control of household pests. Certain types of human behavioral and emotional response to infestations are dependent on income. Behavioral responses are limited to economically feasible means, which limits chemical control to over-the-counter products, and precludes the hiring of professional pest control services.

Another explanation for complacency is tolerance toward the more common pests. Economic constraints and limited resources for control may promote a feeling of hopelessness, or resignation to living with the infestation. Several studies have shown that the greater the infestation, the higher the degree of tolerance,and the more skeptical

residents become about the ability to control the pest (Wood et al. 1981; Zungoli & Robinson 1984).

The impact of level of knowledge on rates of allergenic response also can be inferred; while knowledge in and of itself with have no effect on the incidence of allergy (biological reaction), behaviors associated with that knowledge might (e.g., avoidance, minimizing infestations). A person who is aware that she/he is susceptible to cockroach or house dust mite allergens will probably take greater care to avoid them than the person who is not aware of personal hypersensitivity.

Unfortunately, for the sample of Barbadians, knowledge of pests as potentially harmful did not appear to have much effect on their behavior, with the one exception of the rat, and to a lesser degree, the mosquito and cockroach. Even informants who reported having house dust mites in their homes did not acknowledge frequent dusting as a method of control, or for that matter, any form of control against the house dust mite. Regarding knowledge, it is apparent that Barbadians do not recognize household pests as a threat to the asthmatic; an allergic reaction was only cited a few times and most commonly as an anaphylactic reaction as a result of a sting.

In conclusion, while modernization of the domestic environment was not associated with all of the common household pests in Barbados, it is associated with the most

serious allergen-producing household pest, the house dust mite. A number of pests are common to all householders; at the least, this implies that modernization of the home does not _reduce_ infestations of pests, with the one exception of rodents (found more frequently in poorer homes). The role of modernization and accumulation of allergens other than the house dust mite is not known and deserves further attention. At this point, it is appropriate to analyze the actual incidence of allergy to household pests and confirm the relationship between modernization and infestations of certain pests.

Notes

1. The most recent outbreak of malaria in Barbados reportedly devastated the inhabitants of the Graeme Hall swamp area, Christ Church, in the 1920's (probably _A. aquasalis_) (Nathan, PAHO, personal communication). Prior to the infrastructural changes on the island in the present century, malaria was a significant health problem to Barbadians (Nathan, PAHO, personal communication).

2. M. Brown, M.D., General Practitioner, Brigade House Medical Centre, Hastings, St. Michael, Barbados.

3. An established protocol is in place for Barbadian physicians in the event that a suspicious case of dengue is presented. A standard form is available from the Ministry of Health, which includes a list of 44 "notifiable diseases," of which dengue is one of them.

4. M. Nathan, Entomologist, Pan American Health Organization, Bridgetown, Barbados, W.I.

5. R. Haslett, General Manager, Rentokil (Barbados) Ltd., Culloden Road, St. Michael, Barbados, W.I.

6. J. Williams, Rodent Control Advisor, Pan American Health Organization, St. Michael, Barbados, W.I.

7. Leptospirosis is manifested by signs and symptoms related to liver, kidney, meninges and lung infection, including fever and chills, headache and muscular pain, and sometimes subcutaneous hemorrhage. In about 50% of the cases, jaundice develops, although in a 39-month clinical study in Barbados, 95% of the patients presented with jaundice (Edwards et al. 1990). The disease is sometimes commonly referred to as "black jaundice" (Everard et al. 1984, p.600).

8. The following serogroups and serovars have been identified in Barbados: serogroup Autumnalis, with eight serovars in this group; Serogroup Icterohaemorrhagiae, with two serovars; Serogroup Canicola, with one serovar (canicola); Panama; Pyrogenes; Bataviae; and Ballum (Everard et al. 1984; Edwards et al. 1990; Gale et al. 1990).

9. Of great concern, leptospirosis in Barbados is not limited to the rodent vector, as pathogens have been isolated in the whistling frog, Eleutherodactylus johnstonei (Australis bajan and Autumnalis bim) (Everard et al. 1990a), the toad Bufo marinus (serovars bim and bajan) (Everard et al. 1988), stray dogs (Everard et al. 1987), and the African green monkey (Cercopithecus aethiops sabaeus) (serogroups Ballum, Icterohaemorrhagiae, Autumnalis, Pyrogenes, Panama, Pomona, Tarassovi and Canicola) (Baulu et al. 1987). The monkeys, however, reportedly transmit the disease amongst themselves and pose no threat to humans (Baulu et al. 1987).

10. C. Browne, Rodent Control Unit, Ministry of Health, Jemmott Lane, St. Michael, Barbados.

11. There is some debate as to whether any of the two species of snakes traditionally found in Barbados continue to thrive or not. Leptotyphlops bilineata, the "blind snake," was first identified in Barbados in 1963, near Codrington College (St. John). It is an insect larvae and termite feeder, and lives in leaf litter. Leimadophis perfuscus feeds on frogs and lizards, and lives mainly in the high rainfall regions. It is believed to be unique to Barbados, and was thought to be extinct until recently. Neither species is poisonous (Everard, personal communication; Fraser et al. 1990).

12. Happy Jack Flea Trap, by Happy Jack Inc. 1988. Snow Hill, NC.

13. Fly strips, Olson Products Inc., Medina, Ohio 44258.

14. Trap 'n Kill Roach Killer. Flick Laboratories (Barbados) Ltd. Carmichael, St. George, Barbados, 1991.

15. Tomahawk Live Trap Co., Tomahawk, Wisconsin, USA

16. Mr. Coffee, Inc., Bedford Heights, OH, 44146.

17. Quantification of both assays is dependent on the use of mite extracts with known Der p I or Der f I concentrations. D. pteronyssinus extracts can be sub-standardized against the WHO/IUIS D. pteronyssinus reference (NIBSC 82/518), which contains 12.5 um/ml Der p I. Although no International Reference D. farinae extract is currently available, an in house standard was prepared (UVA 86/01) that contains 16.0 um/ml Der f I.

18. Entomologists include the following: Dr. J.B. Heppner, Dr. J. Kingsolver, Dr. F.W. Mead, and Dr. W. Wirth.

19. It is not possible to comment on differences in numbers of cockroaches by season, because six of the twenty homes refused to participate in the rainy season.

20. Diptera identification was graciously provided by Dr. W.W. Wirth, Division of Plant Industry, Gainesville, FL.

21. Isoptera were kindly identified by Dr. Rudi Scheffrahn, Entomologist, Fort Lauderdale Research and Education Center, Institute of Food and Agricultural Sciences, University of Florida, Fort Lauderdale, FL. Dr. Scheffrahn provided ecological information on the species as well.

22. Pillbugs were graciously identified by Mr. P. Drummond, Entomologist, Santa Fe Community College, Gainesville, FL.

23. Abbott et al. (1982) found that spring mattresses provided better harborages for house dust mites than did foam mattresses, because of the numerous buttons, stitched seams, and bound edges that predominated on the former.

24. The house dust mite's primary source of food is human skin scales. One person produces an estimated 0.5-1.0 gram of dander per day (Korsgaard & Iversen 1991). It has been shown that the amount of dander is not critical to the growth and proliferation of mites, as there is no increase in density when mites are exposed to larger quantities of scales; for example, Korsgaard & Iversen (1991) found that there was no increase in populations in the habitat of a person with psoriasis. Therefore, quantity of food appears to be less of a constraint than humidity and temperature. Relative humidity provides an added nutritional element to mites by enhancing the growth of fungi, that attacks shedded

skin scales, and aids in the digestion of the scales by the mites by either pre-digesting the scales or assisting digestion of scales inside the mite's gastrointestinal system (de Saint Georges-Gridelet 1987; Hallas 1991).

25. As de Boer (1990, p.131) notes, "at higher temperatures, a higher [relative humidity] is required by the mites, ... [and] raising the temperature results in a drop in [relative humidity]." He tested the effect of elevated temperatures on mattress-dwelling mites by covering the mattress with an electric blanket for a prolonged period of time; the majority of the mites were driven downward into the mattress, away from their food sources, and eventually disappeared (de Boer 1990). The implication of these findings on the Barbados setting is the following: Higher temperatures and relative humidity in Barbados during the rainy season could result in elevated nocturnal body temperature that result in a higher mattress temperature and/or a lower relative humidity level than is desirable by D. pteronyssinus, thereby causing a lower density than may be typically seen in other settings.

26. Colloff (1988a) concluded that D. pteronyssinus and Tarsonemus spp. migrated away from the center of the bed because of the dry heat generated by the individual, and that many moved to the pillow region of the bed, near the head of the individual. This of course has serious implications for the asthmatic, as greater quantities of the allergen are closer to the individual's face and the allergen is readily inhaled (Colloff 1988a).

27. This is not a surprising finding, given that most wasps are venomous, even though the evaniid is not. In a household study among apartment dwellers in Virginia, Thoms & Robinson (1986) found that the informants' initial reaction to the idea of introducing the wasp into their home was negative; however, once the informants were educated about the wasp's beneficial role (parasitizes cockroach eggs) and the fact that the wasp was incapable of stinging, their attitude improved. Nevertheless, the evaniid is a hovering-type wasp, frequently seen in Barbadian homes (personal observation), and it was suspected by the author that the combination of frequent encounters in the absence of stings might subdue the negative attitude about the evaniid wasp; this did not prove to be true.

28. M. White, Bayer Caribbean Ltd., Lowland, Christ Church, Barbados. W.I.

CHAPTER 6
THE CLINICAL SETTING: THE EPIDEMIOLOGY OF ALLERGY TO HOUSEHOLD PESTS AMONG BARBADIAN CHILDREN.

Biomedical Testing

The purpose of the skin test was to determine the incidence of hypersensitivity among asthmatic children to household pests. Subsequently, these results were examined to assess the relationship between hypersensitivity and independent variables associated with modernization of the domestic environment.

Biomedical Materials

Subjects

One hundred and sixty-eight asthmatic children between the ages of five and eighteen years were systematically selected from five different polyclinics and one outstation, the Accident and Emergency Department at Queen Elizabeth Hospital, and an urban, private clinic, between the months of June and December, 1991 (see Chapter Two for details on selection of the sample population). Selection of asthmatics was based on a positive history for asthma and physical examination, and criteria included previous attacks, diagnoses and treatment for asthma. Before the biomedical testing commenced at a selected polyclinic, the parent/guardian accompanying the child read and signed a

written informed consent. The parent confirmed that the child had not received antihistamines, ephedrine, or asthma medications 24 hours prior to the testing. In the event that medications had to be administered, the appointment was rescheduled.

The mean age of the population was 9.7 years, and there were 78 girls (46.4%) and 90 boys (53.6%). There was no statistical difference between age in the two groups. The sample was almost equally divided according demographic region (55.4% were urban and 44.6% rural).

Extracts

Extracts used for the skin test were standard, commercially-prepared extracts purchased from Hollister Stier (Hollister Stier Inc., Spokane, WA[1]). Eleven aqueous glycerinated solutions were used; extracts selected included all household pest extracts available which were known to occur in Barbadian homes based on previous taxonomies and the entomological work described in Phase I. Antigens were supplied in 1/10 weight/volume (w/v) dilutions. A glycerinated diluent was used as control. The following extracts were used:

- Control, negative
- Ant, red, red-black
- Cockroach, (*Blattella germanica*/*Periplaneta americana*/*Blatta orientalis*)
- Cricket (*Acheta spp.*/*Gryllus spp.*)
- House fly (*Musca domestica*)
- House dust mite (*D. farinae*)
- House dust mite (*D. pteronyssinus*)
- Mosquito (*Aedes aegypti*/*Culex pipiens*)
- Miller moth (*Heterocera spp.*)
- Mouse (*Mus musculus*)
- Rat (*Rattus* spp.)
- Shellfish (clam/crabmix/lobster/oyster/shrimp/scallops)

Biomedical Methods

The scratch test (epicutaneous) was applied to the volar surface of the forearm after cleansing the skin with isopropyl alcohol. One drop of each extract was placed on a selected site, after which the skin was slightly abraded with a standard scarifier. Each test was evaluated 15 minutes after application, using the scale recommended by Krouse and Klaustermeyer (1980) (Figure 6-1). Interpretations of the test were dichotomous (negative or positive). If the test for a particular extract was "negative," the allergen was administered again using the intradermal test (intracutaneous), applied to the lateral aspect of the upper arm (also cleansed with isopropyl alcohol). A 26-gauge disposable needle and 1-cc syringe was used to inject 0.02 ml of extract solution into the superficial layers of the skin to produce an initial wheal of 5mm in diameter. A negative control was also injected.

The test was evaluated 15 minutes after application, again using the Krouse and Klaustermeyer scale.

Figure 6-1. Graded Skin Test Response (Krouse & Klaustermeyer 1980).

Negative:	0	= control
	1+	= erythema > control
	2+	= wheal 0-4 mm > control
Positive:	3+	= wheal 5-10 mm > control
	4+	= wheal 10 > control or 5-10 mm with pseudopod formation

Interviews

The questionnaire administered in the clinic included sociodemographic information on the child's residence and structural information about the dwelling, symptomatology and preferred modes of therapy, and the informant's perceptions and knowledge about asthma and etiological factors in the child's disease. The questionnaire was both written and oral; after the informant completed the form independently, the questionnaire was reviewed orally and discussed.

Skin Test Results

Individual Extracts

House dust mites

More children reacted positively to the house dust mite allergens than to any of the other extracts; 130 children (77.4%) tested positive to *D. pteronyssinus*, and 125 (74.4%) tested positive to *D. farinae*. More than 82% of the

children were allergic to at least one of the house dust mite extracts (N=138). Similarly, a positive reaction to house dust mite was correlated to more structural and sociodemographic variables than any of the other extracts tested. Allergy to both extracts was related to gender; more asthmatic boys demonstrated hypersensitivity to house dust mites than did asthmatic girls (D. pteronyssinus, X^2=3.924; 1 df, p=0.05; D. farinae, X^2=6.221; 1 df, p=0.01; at least one species, X^2=6.014; 1 df, p=0.01).

Allergy to D. pteronyssinus was correlated positively to moisture-related factors in the home, including the presence of concrete in the structure of the house (X^2=4.365; 1 df, p=0.04), an indoor shower (X^2=4.366; 1 df, p=0.04), and symptoms usually occurring during the rainy season (X^2=15.561; 1 df, p=0.007). Children who were allergic to D. pteronyssinus complained that house dust elicited asthmatic symptoms (X^2=8.23; 1 df, p=0.004). Allergy was also weakly correlated to having a finished ceiling (t=1.7; df=166.0, equal variance; p=0.09), a factor suggesting reduced ventilation.

Allergy to D. farinae was correlated positively to concrete walls at the 0.10 level (X^2=2.935; 1 df, p=0.09), to symptoms occurring most frequently during the rainy season (X^2=8.856; 1 df, p=0.01), and to symptoms worsening when exposed to house dust (X^2=6.25; 1 df, p=0.01). However, reactivity to the two species differed for several

of the independent variables. Allergy to D. farinae--but not to D. pteronyssinus--was related to having carpet in the home ($t=1.83$; $df=166.0$, unequal variance; $p=0.07$), while allergy to D. pteronyssinus--not D. farinae--was related to living in newer homes ($t=2.37$; $df=155.0$, unequal variance; $p=0.08$), homes with finished ceilings, fewer windows, and indoor showers. Table 6-1 illustrates the various relationships between house dust mites in general (reactive to at least one species), D. pteronyssinus, and D. farinae. The likelihood of demonstrating hypersensitivity to at least one of the species was slightly related to wealth ($t=1.66$; $df=166.0$, equal variance; $p=0.10$), although wealth was not a factor for the two species independently.

Crawling insects

Crawling insects included the order Hymenoptera (ants) and Orthoptera (cockroaches and crickets). Of the 157 children tested for allergies to "ants" (Family: Formicidae), 52.2% exhibited positive reactions to the extract. A positive reaction to the ant extract was correlated to only one of the structural and sociodemographic variables--gender of the child; more boys than girls were allergic to ants ($X^2=5.17$; 1 df, $p=0.02$). Also, more children whose symptoms worsened when exposed to house dust were allergic to ants ($X^2=5.10$; 1 df, $p=0.02$).

Sixty children (36.8%) tested positive to cockroach extract. The only variable correlated to cockroach allergy

was the age of the child; older children were more likely to test positive ($t=1.84$; $df=161.0$, equal variance; $p=0.07$).

Fifty children (30.5%) were allergic to the cricket extract. Similarly to the cockroach, cricket allergy was positively correlated to the age of the child; the older the child, the greater the likelihood of cricket allergy, ($t=1.71$; $df=162.0$, equal variance; $p=0.09$). More boys than girls suffered from cricket allergy ($X^2=3.989$; 1 df, $p=0.05$).

Flying Insects

The "flying insects" included the orders Lepidoptera (moth) and Diptera (flies and mosquitoes). Sixty-six children (40.2%) reacted positively to the moth extract. Allergy to moth (Heterocera spp.) was positively correlated to symptoms worsening during the "rainy season" ($X^2=7.257$; 2 df, $p=0.03$), but not to any of the structural or sociodemographic variables.

Sixty-five children (39.9%) were allergic to the house fly (Musca domestica). Allergy to house fly was related to completeness of a finished ceiling; children living in homes with the least-developed ceiling, or no ceiling at all, were more likely to be allergic to house flies ($t=2.25$; $df=115.7$, unequal variance; $p=0.03$). Also, children from poorer families were more likely to be allergic to flies than were children from wealthier families at the 0.10 level ($t=1.70$; $df=157.8$, unequal variance; $p=0.09$).

Table 6-1. Relationship between allergies to house dust mites, *D. pteronyssinus*, and *D. farinae*, and structural and demographic variables (values are derived from a t-test unless indicated by an asterisk, which indicates a X^2 test).

Structural/ socio-demographic variables	House dust mite			*D. pteronyssinus*			*D. farinae*		
	T-value/ X^2*	df	p value	T-value/ X^2*	df	p value	T-value/ X^{2*}	df	p value
Concrete walls	3.246*	1	0.07	4.365*	1	0.04	2.935*	1	0.09
Indoor shower	2.619*	1	0.10	4.366*	1	0.04	0.418*	1	0.52
Wealth	1.66	166.0	0.10	0.75	166.0	0.45	1.14	166.0	0.25
Gender	6.014*	1	0.01	3.924*	1	0.05	6.221*	1	0.01
Symptoms during rainy season	14.553*	1	0.001	15.561*	1	<0.001	8.856*	1	0.01
Symptoms during dusting &/or cleaning the house	11.69*	1	0.001	8.23*	1	0.004	6.25*	1	0.01
Age of home	1.64	29.2	0.11	1.80	39.8	0.08	0.99	50.7	0.25
% of finished ceiling	1.87	166.0	0.06	1.72	166.0	0.09	0.80	166.0	0.43
# rooms with carpet	1.47	166.0	0.14	1.22	166.0	0.22	2.09	95.3	0.07

Fifty-one children (31.1%) were allergic to the mosquito mix extract (Aedes aegypti and Culex pipiens). Allergy to mosquito was, similarly to flies, correlated to not having a finished ceiling at the 0.10 level ($t=1.76$; $df=162.0$, equal variance; $p=0.08$). Mosquito allergy was inversely related to the number of rooms in the house ($t=2.18$; $df=145.9$, unequal variance; $p=0.03$). More boys than girls suffered from allergy to mosquitoes ($X^2=3.633$; 1 df, $p=0.06$), and children whose symptoms worsened during housecleaning and/or dusting were more likely to demonstrate allergy to mosquito ($X^2=4.32$; 1 df, $p=0.04$).

Shellfish

Shellfish were included in the battery of skin testing because they are part of the phylum Arthropoda. More boys than girls were allergic to shellfish ($X^2=6.373$; 1 df, $p=0.01$), and older children tested positive more often than younger children ($t=2.09$; $df=165.0$, equal variance; $p=0.04$). Allergy to shellfish was also correlated to symptoms being worse during housecleaning and/or dusting ($X^2=4.93$; $df=1$, $p=0.03$).

Rodents

Rodents were the only mammal-related allergens tested (extract was derived from the dander and urine). Mice (Mus musculus) and rats (Rattus rattus and R. norvegicus) are frequently-reported household pests in Barbados (see Chapter Five). Yet rodents were the least-common allergies in the

study; only 17 children (10.5%) reacted positively to the mouse extract and 15 (9.0%) reacted positively to the rat extract.

Hypersensitivity to mouse was not related to any of the structural variables except for the presence of carpeting; children with allergy to mouse lived in homes with more carpeted rooms than children without allergy to mouse ($t=2.25$; $df=160.0$, equal variance; $p=0.03$). Older children were more likely to suffer from mouse allergy than younger children, at the 0.10 level ($t=1.74$; $df=160.0$, equal variance; $p=0.08$).

Allergy to rat was inversely correlated to two variables representing poor quality homes; children with allergy to rat were more likely to live in homes with fewer rooms ($t=2.07$; $df=165.0$, equal variance; $p=0.04$) and had fewer indoor water taps ($t=3.30$; $df=22.1$, unequal variance; $p=0.003$). However, there was also an association between an indoor toilet and allergy to rat ($X^2=5.47$; 1 df, $p=0.02$). Allergy to rat was not correlated to wealth. Children whose symptoms worsened during housecleaning and/or dusting were more likely to be allergic to rats at the 0.10 level ($X^2=3.02$; 1 df, $p=0.08$).

Figures 6-2 and 6-3 illustrate the statistical correlations between the 11 extracts and the various sociodemographic and architectural variables. The combined

responses for "allergic to one or more house dust mite species" is also presented.

Cross-Reactivity

Table 6-2 summarizes the number of positive reactions to all household pests tested. Only 15 of the asthmatics tested did not respond positively to any of the extracts, and the greatest number of responses was to five different extracts (22 asthmatics) (illustrated in Table 6-3). More than half (57.7%) of the sample population tested responded to four or more different pests.

Figure 6-4 is a correlation matrix presenting the interrelationships between the skin tests (Chi-square analysis). All of the correlations except for those with the two rodents yielded probabilities at the 0.05 level. The highest Chi-square value was for the two house dust mite species (X^2=73.4).

Allergy to rat dander and urine did not increase the likelihood of reacting positively to any of the arthropods except for mosquito (X^2=9.6; 1 df, p=0.002) and shellfish (X^2=12.7; 1 df, p<<0.001). Surprisingly, hypersensitivity to rat was not associated with hypersensitivity to mouse. Mouse allergy was associated with allergies to more of the arthropods than rat; there was a significant relationship between mouse and five arthropods, including D. farinae, but not D. pteronyssinus.

Correlations to shellfish yielded particularly high Chi-square values, particularly for crickets (34.6), mosquitoes (34.6), ants (34.2), moths (30.1), and cockroaches (26.6). Associations with the house dust mites species were, conversely, relatively weak when compared to the other arthropods.

Table 6-2. Total number and proportions of responses to specific extracts (note: Sample size ranged from 157-168, as indicated under frequency).

Extract	Frequency	Percent
House dust mite (both spp.)	138/168	82.1
House dust mite (*D. pteronyssinus*)	130/168	77.4
House dust mite (*D. farinae*)	125/168	74.4
Ant (mixed spp.)	82/157	52.2
Miller moth	66/164	40.2
House fly (*Musca domestica*)	65/163	39.9
Cockroach (*B. germanica*, *P. americana*, *B. orientalis*)	60/163	36.8
Shellfish (mix)	58/167	34.7
Mosquito (*A. aegypti* & *Culex pipiens*)	51/164	31.1
Cricket (*Acheta* spp. & *Gryllus* spp.)	50/164	30.5
Mouse (*Mus musculus*)	17/162	10.5
Rat (*Rattus* spp.)	15/167	9.0

Table 6-3. Frequency distribution for total numbers of different pests reacted to in the battery of skin testing.

Total number of extracts eliciting a response	Asthmatics responding positively: Frequency	Percent
0	15	9.6
1	14	8.9
2	17	11.0
3	20	12.8
4	16	10.3
5	22	14.1
6	16	10.3
7	08	5.1
8	14	8.9
9	10	6.4
10	4	2.6
11	0	-

	D. pter. &/or D.farinae	D. pteronyssinus	D. farinae	ant	moth	house fly	cockroach	shellfish	mosquito	cricket	mouse	rat
age of home	1.64	**1.80**	0.99	1.54	0.26	0.11	0.15	1.06	0.54	1.60	0.45	0.74
wealth	**1.66**	0.75	1.14	0.17	0.05	**1.70**	0.07	0.94	1.34	0.34	1.06	1.21
cocnrete walls*	**3.25**	**4.37**	**2.94**	0.01	1.88	0.03	0.42	0.53	0.05	0.01	1.49	0.05
% of finished ceiling	**1.87**	**1.72**	0.80	0.14	0.10	**2.25**	0.33	0.31	**1.76**	0.93	0.37	1.39
# indoor water taps	0.54	0.42	0.95	0.35	0.65	0.11	0.62	0.39	1.39	1.10	0.52	**3.30**
indoor shower*	2.62	**4.37**	0.42	2.50	0.75	0.33	0.19	0.14	0.61	0.61	0.13	1.85
indoor toilet*	0.88	1.96	0.12	0.55	1.00	0.09	0.09	0.43	0.19	2.31	0.09	**5.47**
# rooms	1.58	0.71	1.60	0.41	0.17	0.71	0.66	0.22	**2.18**	1.19	1.17	**2.07**
# rooms with carpet	1.47	1.22	**2.09**	0.10	0.71	0.72	0.64	0.29	0.20	0.49	**2.25**	0.20
symptoms to dust*	**11.69**	**8.23**	**6.25**	**5.10**	1.70	0.10	2.13	**4.93**	4.32	0.15	0.82	**3.02**
rainy season**	**14.56**	**15.56**	**8.86**	4.46	**7.26**	3.25	3.81	1.28	1.53	2.70	0.24	1.75
age	**1.71**	1.52	1.21	1.02	1.48	0.81	**1.84**	**2.09**	1.42	**1.71**	**1.74**	1.18
sex*	**6.01**	**3.92**	**6.22**	**5.17**	0.91	1.12	0.05	**6.37**	**3.63**	**3.99**	2.34	1.08

Figure 6-2. Correlation matrix for pest allergies by structural and demographic variables. All values are "t" values (t-test) except when indicated by an asterisk (*), which represents a Chi-square value with 1 degree of freedom, or when indicated by a double asterisk (**), which reporesents a Chi-suare value with 2 degrees of freedom. Significant correlations at the 0.10 level were accepted and are highlighted.

	D. pter. &/or D. farinae	D. pteronyssinus	D. farinae	ant	moth	house fly	cockroach	shellfish	mosquito	cricket	mouse	rat
age of home	0.11	**0.08**	0.33	0.13	0.79	0.91	0.88	0.29	0.59	0.11	0.65	0.46
wealth	**0.10**	0.45	0.25	0.87	0.96	**0.09**	0.94	0.35	0.18	0.73	0.29	0.23
concrete walls*	**0.07**	**0.04**	**0.09**	0.92	0.17	0.88	0.52	0.53	0.82	0.92	0.22	0.83
% of finished ceiling	**0.06**	**0.09**	0.43	0.89	0.92	**0.03**	0.74	0.76	**0.08**	0.35	0.71	0.17
# indoor water taps	0.59	0.67	0.34	0.73	0.52	0.92	0.54	0.70	0.17	0.27	0.61	**0.003**
indoor shower*	0.11	**0.04**	0.52	0.11	0.39	0.57	0.67	0.71	0.44	0.43	0.72	0.17
indoor toilet*	0.35	0.16	0.73	0.46	0.32	0.77	0.77	0.51	0.67	0.13	0.77	**0.02**
# rooms	0.12	0.48	0.11	0.68	0.86	0.48	0.51	0.82	**0.04**	0.24	0.24	**0.04**
# rooms with carpet	0.14	0.23	**0.04**	0.92	0.48	0.47	0.52	0.77	0.84	0.63	**0.03**	0.84
symptoms to dust*	**0.001**	**0.004**	**0.01**	**0.02**	0.19	0.75	0.15	**0.03**	**0.04**	0.70	0.37	**0.08**
rainy season**	**0.002**	**0.001**	**0.01**	**0.10**	**0.03**	0.34	0.23	0.91	0.66	0.32	0.83	0.19
age	**0.09**	0.13	0.23	0.31	0.14	0.42	**0.07**	**0.04**	0.16	**0.09**	**0.08**	0.24
sex*	**0.01**	**0.05**	**0.01**	**0.02**	0.34	0.29	0.83	**0.01**	**0.06**	**0.05**	0.13	0.30

Figure 6-3. P-values for pest allergies by structural and demographic variables. All values are "t" values (t-test) except when indicated by an asterisk (*), which represents a Chi-square value with 1 degree of freedom, or when indicated by a double asterisk (**), which reporesents a Chi-suare value with 2 degrees of freedom. Significant correlations at the 0.10 level were accepted and are highlighted.

	D. pter. &/or D. farinae	D. pteronyssinus	D. farinae	ant	moth	house fly	cockroach	shellfish	mosquito	cricket	mouse	rat
D. pter. &/or D. farinae	X	X										
D. pteronyssinus	--	X										
D. farinae	--	**73.4 (<.001)**	X									
ant	**16.1 (<.001)**	**23.7 (<.001)**	**13.2 (<.001)**	X								
moth	**14.0 (<.001)**	**12.3 (<.001)**	**16.8 (<.001)**	**9.7 (.002)**	X							
house fly	**8.30 (.004)**	**9.5 (.002)**	**12.7 (<.001)**	**14.0 (<.001)**	**19.4 (<.001)**	X						
cockroach	**8.70 (.003)**	**7.2 (.007)**	**10.6 (.001)**	**18.6 (<.001)**	**12.5 (<.001)**	**18.4 (<.001)**	X					
shellfish	**12.7 (<.001)**	**15.6 (<.001)**	**8.7 (.003)**	**34.2 (<.001)**	**30.1 (<.001)**	**18.9 (<.001)**	**26.6 (<.001)**	X				
mosquito	**7.6 (.006)**	**5.4 (.02)**	**6.0 (.02)**	**10.6 (.001)**	**10.8 (.001)**	**25.2 (<.001)**	**28.0 (<.001)**	**34.6 (<.001)**	X			
cricket	**15.5 (<.001)**	**14.2 (<.001)**	**21.0 (<.001)**	**21.9 (<.001)**	**25.9 (<.001)**	**20.6 (<.001)**	**19.1 (<.001)**	**34.6 (<.001)**	**9.7 (.002)**	X		
mouse	**4.1 (.04)**	1.32 (.25)	**4.0 (.05)**	0.15 (.70)	**4.5 (.03)**	0.005 (.94)	0.14 (.71)	**5.14 (.02)**	2.1 (.15)	**4.6 (.03)**	X	
rat	0.187 (.67)	0.74 (.39)	0.02 (.89)	0.13 (.72)	1.9 (.17)	1.84 (.17)	1.10 (.29)	**12.7 (<.001)**	**9.6 (.002)**	**2.7 (.10)**	1.9 (.17)	X

Figure 6-4. Correlation matrix for positive skin tests, indicating the interrelationship between each of the extracts. All values represent a Chi-square test with 1 degree of freedom.

Discussion

Symptomatology

It is difficult to determine at what point in time asthma began to increase in Barbados. From 1951-1955, "respiratory disease" accounted for 18.0% of all infant deaths in Barbados, second only to "congenital debility" at 20.2% (Lowenthal 1957). At that time, the high rate of respiratory-related death was attributed to "overcrowding" and "poorly ventilated homes" (Lowenthal 1957). In a discussion regarding causes for the increasing incidence of asthma in Barbados, the Acting Chief Medical Officer suggested that one possibility is not an increase in cases so much as the likelihood of improved or more uniform diagnostic procedures among physicians. Furthermore, less reliance on home remedies and greater reliance on the formal medical sector, may result in accelerating treatment (Ferdinand, personal communication). However, she did concede that, empirically-speaking, more children with asthma are seen in the casualty clinic than 20 years ago, when she recalls that the majority of cases were adults (Ferdinand, personal communication).

The general consensus among Barbadian parents is that a headcold is a direct result of "getting your head wet" or "catching a chill" in the night air or in the rain. Similarly, the onset of asthma is linked with this

phenomenon. One informant in St. Andrew was asked why he thought asthma was increasing so much in Barbados:

> I'll tell ya why. It's because parents do not watch the children the way they use to. Use to be the children come home from school, they take off they uniforms, and do homework, under the parent's supervision. Nowadays, the children come home from school, they stay outside and play, with they uniforms on, no one to watch them. They stay out even when it start to get dark. They leave the clothes on even if they wet. No supervision. This is the problem. They gettin' sick...

When parents were asked to list all stimulants that might elicit an asthmatic attack in the child, the most common responses were, equally, "housecleaning/dusting" and "spraying insecticides" (N=112, 66.7%), two factors highly related to the theme of this study. A large proportion of responses was related to having a cold, moisture and coolness. In fact, the second-most common response was "when it's humid" (N=95, 56.5%) and not far behind this response was "when the child catches a cold" (N=71, 42.3%). It can be inferred that, because the common belief is that an individual "catches a cold" because he/she is wet or has "a chill," "catching a cold" is also related to moisture and/or temperature. A number of miscellaneous stimulants were reported; most are in keeping with notoriously common allergenic stimulants worldwide, such as certain foods (28.6%), perfumes (4.8%), pollens (3.6%) and grasses (3.0%). Yet other individual responses indicated that contact with

or exposure to moisture and cool temperatures was important stimulants.

Additional correlations with moisture and asthmatic attacks are evident in responses to the question: "When is your child most likely to have an asthmatic attack?" Table 6-5 illustrates that the most important time periods for developing asthmatic symptoms are nighttime (N=111, 66.1%) and the rainy season (N=91, 54.2%). The response that attacks happen most frequently during the night bears significance for several reasons. First, it corresponds to the traditional belief that "night winds" are deleterious to health, and asthma, being a result of such "cold" illnesses (referring to the traditional humoral theory of medicine) as a headcold or respiratory sickness, could expectedly be worsened by exposure to such an element. Second, night temperatures do drop--although the significance of the decrease in temperature is relative by temperate clime standards--by as much as 6° Celsius in the winter months (as low as 25° Celsius, but rarely lower). Bronchial hyperactivity to irritating stimuli in the asthmatic is a well-known phenomenon, and cold air is a common irritant (Kaliner et al. 1987). The third--and perhaps most important implication in regards to the study--is the fact that, during the night, the asthmatic spends the most concentrated time out of a 24-hour period in the domestic

Table 6-4. Frequency distribution of stimulants responsible for an asthmatic attack (N=168).

Stimulant	Frequency	Percent
Housecleaning/dusting	112	66.7
Spraying insecticides	112	66.7
*When it's very humid	95	56.5
After vacuuming/sweeping the floors/furniture	82	48.8
When it's dusty/dry outside	75	44.6
After strenuous exercise	74	44.0
Catches a head-/chest-cold	71	42.3
*When it's cold	59	35.1
After eating certain foods	48	28.6
When it's very hot/sun exposure	39	23.2
Perfumes	8	4.8
When the fruit trees blossom	6	3.6
Smoke/burning trash	6	3.6
Change in emotions	6	3.6
Detergents/soaps/powders	6	3.6
Certain plants/grasses	5	3.0
Dust from marl/sawdust/ construction	3	1.8
Using a sponge/sponge pillows	2	1.2
Stuffed animals	2	1.2
When the cane arrow is out (November, December)	1	0.6
Too many houseplants	1	0.6
*Goes out into the cold without a hat	1	0.6
*Sea mist	1	0.6
*When there's standing water around the house	1	0.6
*Takes a shower too late in the evening	1	0.6
*Gets wet	1	0.6
Breathing felt-tip markers	1	0.6
Exposure to fresh paint	1	0.6
Breathing hair chemicals	1	0.6
Chalk	1	0.6
Taking aspirin	1	0.6
Exposure to nylon	1	0.6
Wax crayons	1	0.6

*Denotes moisture- and temperature-related stimulants.

environment, particularly in and around high-moisture areas of the house (e.g., toilet, shower, kitchen) and for a prolonged period within the confines of a bedroom mattress (potentially infested with housedust mites); these factors are those for which there are possibly a number of household pest allergens.

Referring to attendances to the A&E Department, as reported in Chapter Two, the "rainy season" response reflects the peak number of visits in the very rainy months of October and November, which is reflective of the time of the year when relative humidity is at its highest.

Table 6-5. Time period when child reportedly is most likely to experience an asthmatic attack.

Time period	Frequency	Percent
Annual periods:		
rainy season	91	54.2
dry season	16	9.5
In a 24-hour period:		
morning	27	16.1
afternoon	17	10.1
night	111	66.1
Other:		
school season	7	4.2
temperature changes	7	4.2
cane season (January-May)	4	2.4
after returning from a visit in another locale	4	2.4
after a cold	2	1.2
during summer vacation	2	1.2
when trees are blossoming	2	1.2
after moving to a new development	1	0.6

Individual Allergens

The spatial and temporal distribution of house dust mites in Barbados was discussed in depth in Chapter Five. Generally speaking, D. pteronyssinus was the predominant species, found in all homes tested, and densities were proportionately associated with a concrete structure. Children living in concrete homes, older homes, homes with indoor showers, and homes with finished ceilings--or, homes with features associated with excessive indoor moisture and decreased ventilation--were more likely to involve children with hypersensitivity to D. pteronyssinus than children living in homes without these features. Some associations between densities and structural variables were not found in the entomological survey, and, as previously suggested, the small sample size in the entomological survey may have precluded elucidating associations with some of these structural variables.

The surprising findings are those associated with D. farinae. The entomological survey indicated that D. farinae densities were much lower than D. pteronyssinus--by 1/1000--and found in fewer homes. Nearly the same proportion of asthmatics who tested positive to D. pteronyssinus (77.4%) tested positive to D. farinae (74.4%), and being allergic to one species was highly correlated to being allergic to the other (X^2=73.4; 1 df, p<<0.001). In addition, hypersensitivity to D. farinae was associated (at the 0.10

level) with living in a concrete home. This peculiar association between incidence of allergy to the two species and the independent variables with which they are both associated is highly suggestive of cross-reactivity.

Ants, like other Hymenoptera superfamilies (e.g., bees, wasps, hornets and yellowjackets), are capable of eliciting some of the most serious anaphylactic reactions. Despite the more than 10,000 different species of ants, only ants of the genus Pogonomyrmex and Solenopsis have been implicated in anaphylactic reactions in the U.S. (Stablein & Lockey 1986).

The relatively high frequency of allergies to ants in the Barbados sample was consistent with the literature (Barnard 1973; Harwood & James 1979). Reflective of the associations between frequently seeing ants in the home and structural and socioeconomic variables--or lack there of--allergy to ants was not highly correlated to any of the structural variables.

The international incidence of cockroach allergy varies tremendously; in the Dominican Republic, only 15% of atopics tested positive to a cockroach mix by skin testing (Brenner et al. 1991), Marchand (1966) found 52% hypersensitivity among asthmatics in Puerto Rico, and the incidence has been reported to be as high as 69% among asthmatic children in the U.S. (Kang & Chang 1985). Certainly an important element in evaluating the difference in the incidence of

allergy to cockroaches in the tropics versus temperate regions is the difference in predominant species, and subsequently different behavioral patterns associated with the spatial distribution of the pest. The smaller German cockroach--and to a lesser degree, the oriental--are the most common species in temperate climes, while the larger Periplaneta species are predominant in the tropics. Although each of these species are classified as "domestic pest species," their behavior is markedly different.

The German cockroach is an indoor breeder, preferring a humid environment with an average temperature of 70°F/21°C (Koehler et al. 1987). It is tolerant of crowded conditions, and a population within a given unit/home can be quite large; in a North Central Florida study, the median number of cockroaches found in each apartment exceeded 13,000 (Koehler et al. 1987). Although the American and, to a lesser extent, the Australian, cockroaches are also considered to be domiciliary species, they are less dependent on the indoor environment than are the German and oriental cockroaches, and are somewhat "peridomestic" in their behavior. They are primarily outdoor breeders--particularly in the tropics--and are abundant in out-buildings, dumps and wood piles, cracks and crevices in coral rock, and even palm trees (Cornwell 1968). Therefore, their indoor densities are significantly less than are densities of German cockroaches. When German and American

cockroach populations are present at the same time, the Germans usually outnumber the Americans; ratios of 99.7% German to 0.2% Australian have been reported in three Texas cities, and ratios of 90% German to 1% Australian were reported in North Carolina buildings (Ebeling 1975).

An incidence of 36.8% cockroach positive skin tests, as found in the Barbados study, is higher than that found in the Dominican Republic (Brenner et al. 1991), but lower than what was reported in Puerto Rico (Marchand 1966) and lower than overall incidences in temperate climes (Schulaner 1970; Kang & Sulit 1978; Kang & Chang 1985). What is surprising in the Barbados study is the absence of correlations between certain housing factors and the presence of allergy to cockroaches. The relationship between housing and cockroach allergy in the Dominican Republic has been presented elsewhere in this thesis; it was concluded in that study that the better-built homes provided better habitats for cockroaches, and subsequently, children living in those homes were more likely to suffer from cockroach allergy than were children living in poorer homes (Brenner et al. 1991). Yet no such correlations could be found among the Barbados population.

Frequency of cockroach sightings also was unrelated to any sociodemographic or structural variables, and it was suggested in Chapter Five that this factor possibly was due to the overall pervasiveness of cockroaches throughout the

island, therefore precluding the importance of microhabitat features. The same can be said for the skin test results. However, another explanation--similar to what was proposed in Chapter Five--is that certain features of the microhabitat in Barbadian homes, important for cockroach infestations, were not included in the methodology of the study.

The correlation between age and cockroach allergy is difficult to explain and is, quite possibly, an accidental relationship, as nowhere in the literature could similar relationships be found. Children are expectedly exposed to the same domestic environment from infancy to adolescence, so an increase in exposure at home is not expected, at least not in the general sense (possible exceptions include moving to a new home, upgrading the home). One possibility is exposure outside of the home; for example, cockroaches are sighted frequently in commercial areas such as supermarkets. Indeed, places where goods are imported are typically the only locales where German cockroaches (Blattella germanica) can be found in Barbados. Cornwell (1976) reported on tropical infestations of both German and American cockroaches in the marketplace and supermarkets. It may be that older children visiting supermarkets or the like, or who are increasingly consuming goods from the supermarket that are contaminated by cockroaches (e.g., canned beverages, snack food), are increasingly exposed to ingested

allergens; elsewhere, hypersensitivity secondary to ingested arthropod allergens has been discussed (Bernton & Brown 1967). However, this hypothesis is difficult to defend because children who were not allergic to cockroaches were only slightly younger (mean=9.30 years) than children who tested positive (mean=10.32).

Crickets are best classified as "occasional household pests," and typically migrate indoors when grasses--their natural food supply--dry and/or become scarce (Ebeling 1975). They are also attracted to light. Field crickets (genus Gryllus) do not successfully maintain populations indoors as do House crickets (genus Acheta). Acheta species deposit their eggs in crevices and other dark places in the home, attracted by the warmth of the domestic environment, and sometimes destroying clothing, synthetic fabrics and carpeting (Ebeling 1975).

The relationship between hypersensitivity to cricket and household density may be secondary to the warm, moist environment created by greater numbers of people in a confined area, a phenomenon described by Hansen (1984), and the provision of food sources, such as clothing. An association between age and cricket allergy, as well as more boys with cricket allergy, may, as in the case of cockroach allergy, represent behavioral factors. However, as with the cockroach, there was little difference in the mean age of

the children who tested positive to cricket (mean=10.34 years) and those who tested negative (mean=9.36).

Insects under the order Lepidoptera are particularly allergenic; of 53 different arthropod species, (Wirtz 1980) found that the predominant sources of allergic reactions were different species of Lepidoptera (an incidence of 67.0%). In Japan, more than 50% of asthmatics exhibited hypersensitivity to silkworm, butterfly, and moth allergen (Kino & Oshima 1978). The most important allergenic component in Lepidoptera is believed to be the wing scales (Wirtz 1980).

In the Barbados study, hypersensitivity to the moth extract was not related to any of the independent variables; again, possibly due to the pervasiveness of the insect; moths were the tenth-most frequently seen pest out of 37 pests, and were cited as "usually/always" around the house by 44.6% of the subsample that answered the pest-related questions (Chapter Five).

House flies depend on warm, moist materials for laying their eggs, including animal excrement, decaying fruits and vegetables, garbage, and contaminated soil (Ebeling 1975). The fact that many Barbadians--including those in the urban sector--keep fowl and stock around the house supports the fact that flies were frequently listed as one of the most common household pests by informants in the study.

Although little attention has been focused on allergy to flies in the scientific literature (Ebeling 1975; Bellas 1983; Baldo & Panzani 1988), their sheer number in both urban and agricultural settings implies that they may be of great antigenic importance. Hypersensitivity to the fly extract was just slightly less than that to moth, and it was the fifth-most common allergy overall. The association between fly allergy and not having a finished ceiling suggests a greater ease of access into the home (due to the open space between the wall and rafters) and, subsequently, greater numbers of flies in the home.

Of all the biting insects, mosquitoes are perhaps the most common worldwide, and yet, systemic allergic reactions to mosquitoes appear to be quite rare (Hoffman 1986), although localized allergic reactions due to the injected oral secretions during a blood meal have been described (Harwood & James 1979). Wirtz (1980) reported a number of occupational-related allergies (entomological workers) to mosquitoes; similarly to Lepidoptera, the wing scales were implicated as the main source of the allergen.

The only association between mosquito allergies and architecture was, similarly to flies, related to ease of access into the dwelling (unfinished ceiling).

Shellfish were included in the skin test battery, despite the fact that they are not typically consumed by the average Barbadian. Shellfish in Barbados are prohibitively

expensive and are consumed much more commonly in restaurants and tourist resorts than by the locals. Nevertheless, as arthropods, shellfish have been implicated as significant allergens to asthmatics (Baldo & Panzani 1988). For the study population, the only significant demographic associations with shellfish allergy were for older children and more boys than girls. The fact that allergy to shellfish (34.7%) was more common than allergy to the common mosquito (31.1%) once again suggests the phenomenon of cross-reactivity.

Another possible explanation for the incidence of allergy to shellfish, despite the probable low rate or absence of consumption, is chronic exposure via inhalation. It is possible that living near the sea and/or play activity near fishing piers and markets increases the likelihood of inhaling aerosolized components of shellfish. It can be postulated that there might be a difference in the degree of exposure to such allergens, depending on which side of the island an asthmatic lives (tradewind variation).

Hypersensitivity to the two rodents was the least-common of all the skin tests. Rodents had been included in the battery because they are reportedly common in Barbadian homes (Chapter Five) and are referred to in the literature (Wirtz 1980; Longbottom & Austwick 1987; Price & Longbottom 1987), although studies have been based primarily on laboratory workers. Nevertheless, if one of the most common

means for acquiring leptospirosis is via indirect contact with rat urine, it was hypothesized that indirect contact with allergens in the urine might be a real hazard to Barbadian asthmatics.

Allergy to the two rodent extracts were inconsistent regarding correlations to the structural variables, and for the findings in the entomological survey (Chapter Five), whereby allergy to rodents--especially mice--was correlated to living in poorer homes. But according to the skin test results, mice appear to have an affinity for homes with carpet. No explanations can be offered for this factor. Additionally, while hypersensitivity to rodents is associated with living in a home with few bedrooms and few indoor water taps, the fact that it was also correlated to having an indoor toilet suggests that the number of children reacting to the rat were too few to derive real conclusions.

Allergy to several of the pests was correlated to age of the child, although all but one of the correlations (the shellfish) were significant only at the 0.10 level ("one or both" house dust mite species, cockroach, cricket, and mouse). The importance of duration of exposure has been presented (Wirtz 1980; Brenner et al. 1990); the more frequent the contact with an allergen, the more likely that contact will result in hypersensitivity. The problem is compounded by the presence of "generic" allergens that are common to different species, whereas the development of

allergy to one pest predisposes an individual to develop allergies to other pests. Consequently, older children are more likely to have come into contact and may even experienced prolonged contact with a given allergen, that subsequently renders them hypersensitive to other pest allergens, to which they have not necessarily been exposed.

The relationship between hypersensitivity to a given pest allergen and gender is more difficult to explain; similar findings have not been presented in the literature. In the Barbados sample, more boys than girls responded to the extracts of house dust mites, ant, shellfish, mosquito, and cricket. Although the literature supports the finding that boys are more likely to develop asthma than are girls, the Barbados sample was almost equally divided between asthmatic boys and girls; subsequently, this finding is not related to the makeup of the sample. Certainly a possibility is a genetic predisposition for boys to respond to arboallergens more than for girls. Another possibility is behavior (e.g., play, daily routine) that is different between boys and girls, and subjects more boys than girls to certain allergens (duration of exposure). Worth (1962) found that, not only did Chinese children demonstrate higher incidences of atopic dermatitis than did Japanese and Caucasian children, but the incidence was higher for Chinese boys than for girls. Worth suggested the following: "An extrinsic physical agent--probably a food--preferentially

offered to Chinese boys in affluent families is the most likely explanation of these statistically significant discrepancies" (1962, p.31).

Cross-Reactivity

Studies aimed at identifying the specific allergenic proteins in arthropods have indicated that some of the antigenic determinants are shared by different arthropods (O'Neil et al. 1985; Baldo & Panzani 1988; Solomon & Mathews 1988; Helm et al. 1990). Research on house dust mites found that at least one of four major allergens was shared by *D. pteronyssinus* and *D. farinae* (Solomon & Mathews 1988).

Similarly there is increasing evidence of cross-reactivity among cockroach species. The introduction of the Asian cockroach (*Blattella asahinai* Mizukubo) into Florida has provided the opportunity for testing cross-reactivity among patients not previously exposed to the Asian cockroach, but who are known allergics to other species of cockroaches. Pooled serum IgE from a Chicago sample recognized proteins from Asian, German (*Blattella germanica* (L.)), oriental (*Blatta orientalis* (L.)) and American (*Periplaneta americana* (L.)) cockroaches (Helm et al. 1990). Further studies with the Chicago serum pool have revealed cross-reactivity to *Blattella vaga* (from the arid Southwest) and *Blattella lituricollis* (from rural Hawaii) (Brenner & Helm, personal communication).

Cross-reactivity among various families and even orders of insects also has been reported. Baldo & Panzani (1988) found hypersensitivity to five different orders of insects in an Australian study. Preliminary data suggests shared proteins between cockroaches and sowbugs (Brenner, personal communication). In another study, cross-reactivity was implicated in such diverse arthropods as house dust mites, cockroaches, crabs, shrimp and crawfish (O'Neil et al. 1985). While little specific evidence of cross reactivity with hymenoptera venom and biting insect saliva exists, it has been noted that many atopics who react seriously to insect bites have a history of serious reactions to Hymenoptera venom (Hoffman 1986). In the Barbados sample, hypersensitivity to the ant extract was highly correlated to hypersensitivity to the mosquito extract (X^2=10.6; 1 df, p=0.001).

Summary

In summary, the biomedical testing confirms the extreme importance of house dust mites in allergy disease among Barbadian asthmatics; among all household pests tested, hypersensitivity to the house dust mite was overwhelmingly the most common, affecting more than three-quarters of the sample. These findings support those from a study in Barbados 20 years ago, and are consistent with international findings. Sociodemographic, architectural, and symptomatological variables support the concept that allergy

to house dust mites is positively correlated to modernization of the domestic environment, and is particularly pronounced in the rainy season.

Incidence of allergy to other pests that are reportedly not common in homes (e.g., moths, crickets) and for which previous contact is unlikely (shellfish) suggests a substantial degree of cross-reactivity and/or extreme allergenicity of these species. For those pests in which allergy was demonstrated, the general lack of association between allergy and structural variables implies widespread infestations regardless of development of housing (e.g., cockroaches, ants); this feature was described in Chapter Five. The generally low incidence of allergy to the two rodents suggests that arthropods are much more serious domestic allergens than mammals, despite similar degrees of exposure.

Notes

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CHAPTER 7
SUMMARY AND IMPLICATIONS FOR FUTURE STUDIES

Asthma as a Disease of Modernization: Concurrence with the Theoretical Construct

Review of the Findings

A review of modernizing the domestic environment in a tropical, developing country, an entomological survey focusing on household pests, and biomedical testing for hypersensitivity to common arboallergens and other household pest allergens, all suggest that allergy fits into the theoretical construct of the epidemiological transition. Therefore, the null hypothesis of this thesis has been rejected; modernization of the home does influence the incidence of asthma, by promoting a favorable environment for arboallergens responsible for hypersensitivity.

An initial review of the etiology of human allergy indicated that type I hypersensitivity--or rather, its mediating factor, IgE--appears to have played a beneficial role in minimizing severe morbidity in early humankind, by curtailing the establishment of large worm populations in the human host. However, the transition of human society into state-level modes of production changed the macroenvironment not only at the infrastructural level, but epidemiologically as well, by means of subjecting large

populations to a new host of diseases. The continuing development of medical science and technology drastically reduced the incidence of many acute, high-mortality diseases; yet negative changes in lifestyle (e.g., diet, activity) and exposure to foreign chemicals, proteins, and other materials, contributed to the rise in chronic disease. One of those chronic diseases--although realized at times in an acute condition (anaphylactic reaction)--is asthma.

Asthma was selected as a disease for study because of its alarming increase internationally and the apparent interrelatedness of genetics and behavior. Barbados was chosen as a site of research because of a seemingly exponential increase in the incidence of asthma over the last decade. The focus of hypersensitivity to household pests was selected because of the well-known allergenicity of various household pests and previous studies that have indicated a relationship between the development of the domestic environment and household pest infestations.

The first step in this study was to qualify the concept of "modernization" of the domestic environment. This was achieved by reviewing the sociohistorical evolution of the Barbadian home. The review highlighted a unique phenomenon: There is a disproportionate level of home ownership compared to land ownership in Barbados, primarily due to the socioeconomical history of the island, in which early land distribution patterns, based on a sugar economy, dictated a

social stratification pattern that would persist until the decline of the industry from which it emerged. In short, early success in large-scale sugar production mandated a large-scale labor force, but the small size of the island, coupled with a low rate of absenteeism, restricted the distribution of land, and resulted in a majority population of landless proletariats. The landlessness of the majority was epitomized by a house form that was moveable, and that precluded the integration of permanent materials and amenities such as plumbing, thereby limiting improvements in standard of living.

Consequently, owning one's house spot became an aspiration of many, and one that was best exemplified by the use of concrete in the structure because concrete is permanent, and a concrete house cannot be moved. A trend was observed in the asthma study; having a concrete home was related to owning the land, and when people speculate on their "dream house", it typically is a house made of concrete. Other reasons for preferring a concrete home include sturdiness (e.g., fire resistent, resistance to climatic elements and termites) and low-maintenance. Yet the prohibitive cost of building a concrete home instead of a wood home mandates piecemeal construction. Construction by the lay person may result in minimizing or negating altogether certain architectural principles that would preclude excessive moisture in the home (relative humidity)

and maximize ventilation. Specifically, the data indicated that a number of elements known to affect humidity and ventilation are part of the modernization process, and include: The use of concrete, the installation of indoor toilets and showers in the back of the house (the region of poor airflow), the installation of more indoor water taps, crawl spaces, and finished ceilings (lowering the height of the ceiling and creating a dead air space).

The entomological survey revealed a host of pests that are common in Barbadian homes. However, at least one of those species present in all homes tested--the house dust mite, D. pteronyssinus--thrives best in concrete homes, probably because of the moisture generated and/or the creation of a microhabitat that is favorable over a wood home. Other pests also are very common (e.g., Periplaneta spp. cockroaches, mosquitoes, house flies) and are potentially widespread arboallergens throughout the home. There were no apparent differences in pest distribution on the island, with few exceptions; flies were a particular problem in homes with livestock, and mosquitoes were less of a problem to residents on the windward coast. German cockroaches were found only in urban and semi-urban homes. The differences of rainfall on the island did not affect house dust mite densities or frequency of sightings of other pests; it has been proposed that the overall humidity level

on the island precludes differences in spatial distribution of household pests.

Skin tests confirmed the importance of the house dust mite as a serious allergen; 77.4% of the children tested were skin test positive to D. pteronyssinus, and nearly as many (74.4%) were allergic to a separate species, D. farinae, which was much less prevalent. The high incidence of hypersensitivity to D. farinae illustrates the importance of cross-reactivity in insect allergy and implicates the role of other arthropods that are less common in the home, or even absent (e.g., shellfish).

Most importantly, hypersensitivity to D. pteronyssinus was significantly correlated to living in a concrete home. This correlation supports findings in the entomological survey: House dust mite allergens are more prevalent in concrete homes than wood homes.

Hypersensitivity to other pests was less common; some of those pests tested were those reportedly uncommon in Bajan homes (e.g., moths, crickets), others were pervasively present in all homes (according to ethnographic information and entomological trapping), and one of the allergens, shellfish, was an allergen for which previous contact was unlikely. The absence of interrelatedness between hypersensitivity to these allergens and structural variables implies that, either the appropriate microhabitats (harboring the arboallergens) were not considered, or there

was a substantial degree of cross-reactivity in the sample population, or both. The low incidence of hypersensitivity to the two rodents suggests minimal contact with rodent-borne allergens and illustrates the overwhelming importance of arboallergens over most other types of indoor allergens, at least in the Barbadian setting.

Modelling the Variables

Having identified key variables in predicting the modernization of housing, and subsequently, the development of a microhabitat favorable to one of the most important arboallergens, the house dust mite, the variables were modeled using the SAS logistic procedure (SAS Institute 1988). Equations of the models are presented in Figure 7-1.

A sociohistorical perspective of land ownership was presented in Chapter Three, and data from Chapter Four supported the review. When the independent variables were modeled, a pattern is observed: Owning one's house, plus a relative degree of wealth, plus living outside of the heavy urban sector, are predictive for owning the house spot (model correct 67.2% of the time).

As presented, once a household owns the land, the family is more likely to integrate concrete into the dwelling, or build a new concrete structure altogether. From that point, and/or in the interim, a number of moisture-related elements are added to the structure. Using the logistic procedure, a pattern emerged: Living in a

concrete structure could be predicted by having a concrete foundation, having a number of indoor water taps, and having a greater number of rooms than homes that were wood (model correct 79.1% of the time). Furthermore, a personal profile was modeled: Informants who lived in a concrete home had fewer family members living in the structure, owned the house spot, and were more likely to be legally married, than informants living in wood homes (model correct 55.9% of the time).

Various indoor elements responsible for high, indoor relative humidity were discussed in Chapter Three. Almost all of these elements were characteristic of concrete homes in Barbados. According to Hansen (1984), cooking with a gas stove and dish-washing are two of the most significant contributors of moisture in the house; it is important to note that gas is the predominant stove-type in Barbados. Another important moisture source is showering, which produces 0.23 liters of moisture per day in a 1200 square foot home (Barbadian homes are much smaller than this). In the ethnographic survey, it was noted that shower stalls were often covered with mold and fungi (personal observation). This is probably because they are typically situated in the back of the house and have very small windows placed on one wall only; these factors result in poor air flow and subsequently high relative humidity. When modeled, having an indoor shower was dependent on having

concrete walls and a significant number of indoor water taps (model correct 89.3% of the time).

The allergens that elicited the greatest number of responses were the house dust mites, D. pteronyssinus and D. farinae. The former was found in all homes in which densities were surveyed, and densities were highest in concrete homes (see Chapter Five). In Chapter Five, the ecology of the house dust mite was discussed, and it was noted that house dust mites thrive in warm, humid environments.

When hypersensitivity to D. pteronyssinus was modeled, it was found that both living in a concrete home and having an indoor shower were predictive for demonstrating hypersensitivity to D. pteronyssinus (model correct 69.6% of the time). An even stronger relationship was established for hypersensitivity to D. pteronyssinus and/or D. farinae: Allergy to one or both species was predicted by complaining of symptoms worsening during housecleaning and dusting, symptoms being worse during the rainy season, and living in a concrete house (model correct 72.6% of the time).

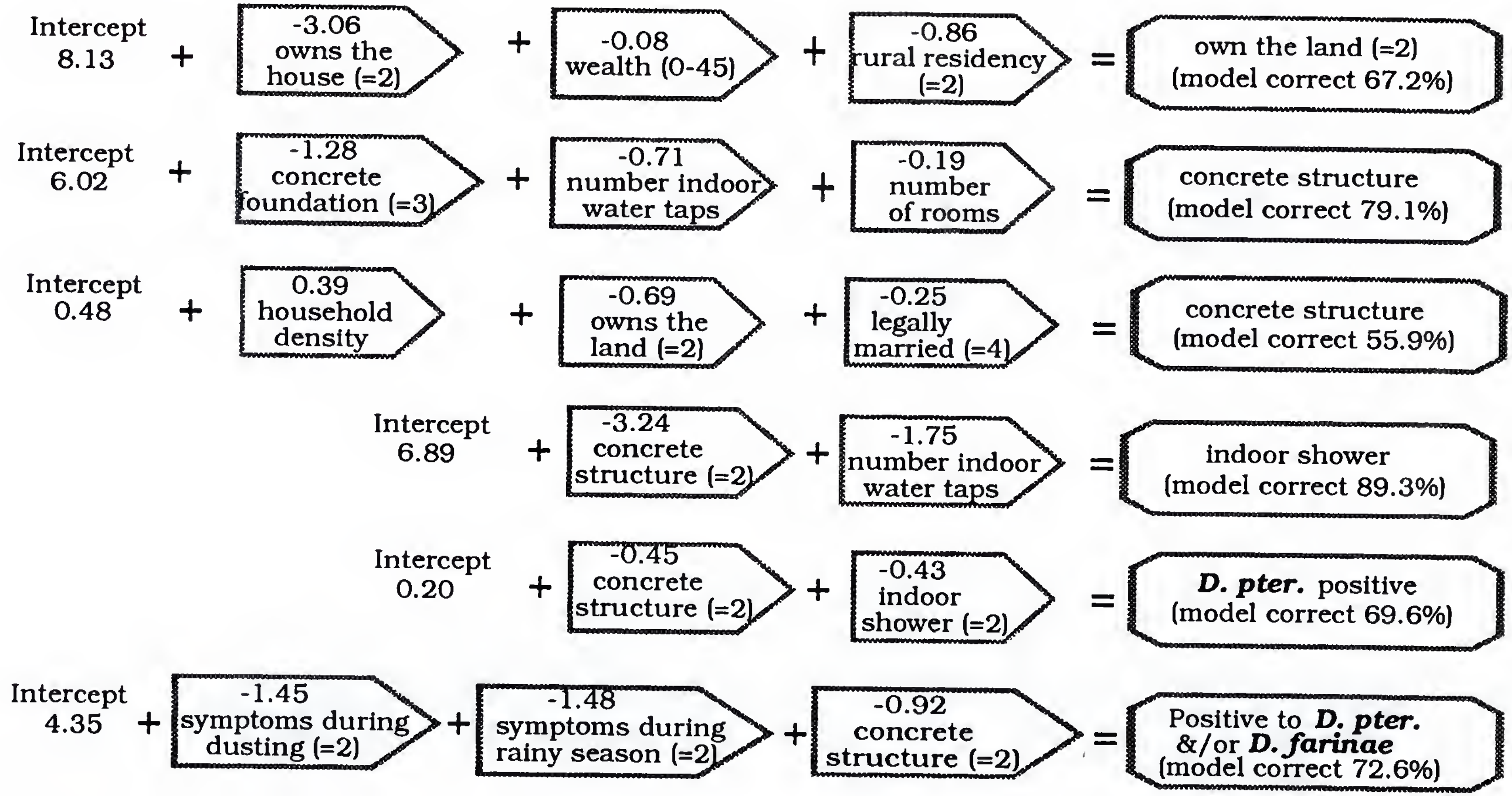

Figure 7-1. Modelling the variables: A summary. Coefficient is displayed above the variable; ranges for values are in parentheses. Dependent variables are in form log (p/1-p) (Analysis of Maximum Likelihood Estimates, SAS Inst., 1988).

Implications for Community- and Household-Level Management of Pests

Previous studies in tropical, developing countries indicate that community education and participation are crucial in the success of eradication of and preventive programs against disease-causing vectors (schistosomiasis, Webbe & Jordan 1982; dengue, Armada & Figueredo 1986; yellow fever and dengue, Le Maitre 1990). Armada and Figueredo (1986) noted that, during the Cuban dengue epidemic, health education aimed at stressing the importance of basic sanitation was believed to have been the most important element responsible for the program's success.

Essential to the success or failure of control programs is the dissemination of information to the householders so that projects may be implemented to their fullest (LeVeen & Willey 1983). For example, a poor understanding of the purpose and benefit of ultra-low volume spraying against *Aedes aegypti* mosquitoes was evident in the Barbados sample, in that several informants admitted to "shutting up" the house when they heard the trucks coming, because of "the bad odor" from the insecticide. In contrast, the importance of community education and participation at the household level is evident in the anti-leptospirosis campaign in Barbados. More than 93% of the sample correctly identified the vector for leptospirosis, but only 75% identified the vector for dengue; this fact is alarming given the pervasiveness of the mosquito versus the rat and the greater length of time that

dengue has been a disease of concern in Barbados (compared to leptospirosis). Moreover, nearly all of the informants could identify one or several means for controlling rodents and subsequently leptospirosis, whereas a much smaller proportion (35%) were able to identify means for controlling the mosquito.

LeVeen and Willey warn that, regarding successful pest control in the domestic setting, management must be viewed as beneficial to the homeowner, because residents "pursue pest management to achieve certain general goals" (1983, p.24), vis a vis protecting one's property (e.g., against termites), preventing disease (e.g., the management of rodents), and maintaining "aesthetic values" (e.g., an extreme dislike for certain pests, and not wanting them in the vicinity of the home). Ethnographic data from the Barbados sample suggested that aesthetic properties were perhaps more important than the perception of a pest as a threat to health; wanting to destroy a pest was more highly correlated to being "disgusted" by that pest than perceiving the pest as "harmful." Also, larger pests (rats, large centipedes, Blaberus spp. cockroaches)--pests that were less frequently sighted in and around the home--evoked a greater level of disgust and desire to kill than the smaller, more frequently-seen pests.

All of these factors suggest that, in designing a control strategy, particularly for small, common pests--such

as the house dust mite--a thorough investigation regarding the negative perceptions of that pest must be implemented prior to designing a control strategy, and the findings from that study must be capitalized and integrated into the strategy. For example, the author recommends that, because asthma has become an island-wide concern (and quite possibly affects at least one extended family member or acquaintance of every household in the island), the life-threatening potential of household pests (e.g., the house dust mite) should be emphasized. In addition, emphasis should be placed on the very negative characteristics of pests such as the house dust mite (e.g., a pest that feeds on human skin scales, a pest that is present in one's bed).

Implications for Patient Education

In keeping with the theme presented by LeVeen and Willey (1983), control strategies for highly allergenic pests should be presented to the asthmatic and her/his family as a means to prevent disease. Studies have demonstrated that the degree of exposure to *Der p* I in infancy increases the risk of asthma in childhood (Sporik et al. 1990). Others have indicated that a significant reduction of densities in the home can improve symptoms and even reverse bronchial hyperactivity (Pollart et al. 1987). Such information should be presented to the parent of an asthmatic child as a stimulus to control all pests--even

microscopic or rarely seen pests--in the domestic environment.

In the Barbados study, both "house dust" and "spraying insecticides" reportedly elicited asthma-related symptoms more frequently than any of the other stimuli, for 66.7% of the children. These two points should be central in the direction of patient education, by: (1) Explaining that the house dust mite is the major component in house dust in general, and therefore illustrates the danger of house dust to the asthmatic child; and (2) alternative modes of pest prevention (e.g., screens, food containment) should replace the heavy reliance on chemical control.

In developed countries, there exists an almost standard protocol presented to asthmatics and their families for minimizing house dust and house dust mites. This includes frequent vacuuming, preferably with water trap/double-filter vacuums, air filters in climate control devices, dehumidifiers, and acaricides (Pollart et al. 1987; National Asthma Education Program 1991). A recent study indicated that the use of computer-aided education was effective in reducing allergen levels of house dust mites (Huss et al. 1992). While these methods of control can be very effective in reducing densities of house dust mites, a number of constraints in the tropical, developing setting preclude their use.

Financial constraints

Despite the U.N. classification of Barbados as a "more developed" nation, the standard of living in Barbados is modest compared to developed countries, and most of the above recommendations are restricted to the highest socioeconomic strata. It was discovered in the asthma study that, although more than half of the householders had carpet in the home (N=103), most residents did not own a vacuum-cleaner. However, a common practice for cleaning carpets and upholstered furniture is to remove the objects from inside the home and clean them outside, allowing them to dry in the sun. Unknowingly, residents are destroying most of the fungi and mites in this process. Explaining this added benefit to their behavior--killing the elements that wreak havoc on the asthmatic--may encourage them to increase the frequency of this behavior, thereby reducing the density of aeroallergens in the home. This is obviously a very inexpensive means for environmental control.

Financial constraints preclude the use of items other than vacuum cleaners in Barbados. The most affordable chemical control for pests is over-the-counter insecticides, most of which are designed to kill flying and crawling insects, and none of which contain acaracides. Just over a third of the asthma study respondents had ever used professional pest control, and 62% of those respondents had only used it one time; therefore, it is apparent that this

service is restricted to the wealthy Barbadians. Also, relatively inexpensive items in developed countries, such as plastic mattress and pillow coverings, can be prohibitively expensive or even unavailable in a developing country.

Structural constraints

Any of the usual recommendations involving climate control are irrelevant in the Barbadian setting; as previously explained, indoor climate control is nonexistent in even the wealthy Barbadian homes and is limited to businesses and tourist hotels and apartments. A dehumidifier, even if affordable, would be futile in a structure constantly open to the outdoors. Perhaps another solution might be the increased use of electrical fans--particularly ceiling fans--for the circulation of indoor air and subsequently the lowering of indoor relative humidity. Education of ideal habitats for allergens such as the house dust mite, molds, and fungi (e.g., shower and toilet stalls with poor ventilation), and the importance or aerating these spaces (e.g., via fans, larger windows) may function to further reduce indoor relative humidity where it is most critical.

Although nearly 85% of the informants recognized cockroaches as "indoor pests", the most common perception as to why cockroaches were attracted to the indoors was related to food; none of the informants acknowledged the importance of indoor water sources as attractants to cockroaches, even

though they were most commonly sighted in and around the kitchen, toilet, and shower stall (personal observation). Public education regarding the importance of eliminating rodent habitats to prevent leptospirosis has been implemented and, impressively, cited by nearly 85% of the sample population, the reduction and/or elimination of other pest habitats should also be encouraged. Knowledge of the importance of plumbing as an attractant to cockroaches may promote stringent housecleaning in these areas of the home, and in turn, reduce the level of molds, fungi, and other allergens.

The addition of concrete in the home, which in turn leads to the addition of concrete foundations, increasing numbers of indoor water sources, and a host of other moisture-related and decreased ventilatory principles, has been examined in the Barbadian setting. Built under ideal conditions, these features are not necessarily deleterious; however, as presented, many Barbadians are financially restricted from the use of building contractors, or the systematic construction of their homes. This results in building practices that promote excessive moisture accumulation, including wicking (e.g., absence of a moisture barrier, wet soil, construction during the rainy season), and the placement of high-moisture sources in poorly-ventilated regions of the home (e.g., toilet and shower stalls in the back of the house).

Data presented in Chapter Four illustrate that residents do not care for screens, although the style of window they are adopting is appropriate for screens. Screens in the windows would at least reduce the volume of dust collecting inside the home. Education as to the source of aeroallergens--many from the outdoors--may encourage clients to incorporate screens in the structure of their home.

Environmental constraints

It has been demonstrated that the overall daily relative humidity level in Barbados are far greater than the highest annual levels in temperate climes, where most studies have taken place. This factor compounds modernization features that promote the production of pest-related allergens, by providing the optimal macroenvironment for almost every pest discussed thus far. Educating asthmatics and their families as to the important role of relative humidity in the worsening of symptoms can reduce the level of disease in the rainy season. Providing information regarding various moisture sources (e.g., wet concrete, poor drainage of water around the house, collection of water in crawl spaces) may promote behavior that would, ultimately, reduce the indoor relative humidity level.

Ideological constraints

A repeated theme throughout this dissertation has been the integration of concrete in the Bajan home, and the historical and sociological basis for this integration--social status. This feature must be recognized as not simply a fad, or even a trend, but the real direction of contemporary housing in Barbados. The benefits of concrete housing over wood probably outweigh the health-related costs outlined in this work for the majority of the population, considering the greater durability of concrete against tropical storms and pests, the availability of concrete versus the absence of timber on the island, and lower overall maintenance of concrete versus wood (e.g., wood rot).

The example of screens in windows--or a lack thereof--is both a structural and ideological constraint. Referring again to Chapter Four, most of the reasons for not using screens in the windows were purely aesthetic. Similarly, other structural features of the home, described as promoting a warm, moist, low airflow indoor environment, reflect a trend based on emulation to homes in developed countries (in very different climates), commercial availability and, in general, visual appeal. Recognition of the ideological importance of this transition in housing must be integrated into the planning and development of a preventive strategy.

Implications for Further Research

Due to financial and time constraints, only the potential aeroallergens of the house dust mite were quantified and examined spatially and temporally within the home. The pervasiveness of house dust mites in the entomological sample reflect the high incidence of hypersensitivity to their allergens. Entomological sightings and ethnographic data suggest that other pests--particularly cockroaches, house flies, and mosquitoes--are also pervasive pests, common in all Barbadian homes, regardless of socioeconomic status and, in most cases, regardless of house-type at the macro-level. Nevertheless, the incidence of allergy to these pests was relatively low, compared to the house dust mite. One explanation is of course the predominance of house dust mites compared to most other allergens in the home (Buchanan & Jones 1972; Kang & Sulit 1978; Dowse et al. 1985; Massicot & Cohen 1986; National Asthma Education Program 1991). Another possibility is that other arthropods are less allergenic than house dust mites. However, an additional explanation is the suitability of a particular house-type as an ideal microhabitat for aeroallergens of other pests; it is possible that many homes, for reasons not identified in the current study, do not support the presence of large numbers of arboallergens because of structural and/or behavioral factors. This issue deserves further investigation.

Another factor not considered in the entomological survey was the seasonal difference in pests other than the house dust mite; again, because these pest populations were not quantified, it was not possible to state with certainty temporal variations in population levels. However, perhaps in the tropical setting, pests favor the domestic environment more at certain periods than others; this too, requires additional research. For example, due to an unlimited supply of moisture at the macro-level, perhaps cockroach infestations are greater during the dry season. Lowenthal (1957) noted that flies were most common when cane fields were being fertilized, between July and October. Perhaps heavy fly populations and, subsequently, large densities of aeroallergens from flies, are a particular problem for those households in the agricultural sector, but not for the urban sector. Temporal distribution patterns of arboallergens are important to the design of preventative protocols (e.g., avoidance measures to take in the home, and <u>when</u>).

There is a definite seasonal pattern in the worsening of asthmatic symptoms and attendances to the A&E Department in Barbados. Data revealed that there was no significant difference in temporal distribution of house dust mites, and most informants did not cite significant differences in the frequency of household pest sightings according to weather. It is possible that other indoor allergens, such as molds

and fungi (which thrive in moist environments), are significant aeroallergens in the morbidity of asthma during the rainy season.

The deleterious elements related to concrete housing must be identified, potential behavioral and structural modifications must be focused upon, and a plan to implement these modifications should be designed and conducted. The objective of this project was to identify those elements--this has been met. Findings suggest the importance for a longitudinal study, analyzing the effects of behavior modification directed at reducing the level of arboallergens in the home, thereby reducing the risk of exposure to allergenic substances. The Barbadian environment presents with features quite different than those seen in temperate locales, necessitating a preventative protocol designed specifically for that population. Clearly, chemical pest control is a <u>reactive</u> means of control; <u>preventative</u> means are required to tackle the increasing incidence of asthma in developing countries.

In summary, the ramifications of these findings are crucial to Barbadians and, for that matter, any atopic individual residing in a tropical environment undergoing urbanization and modernization. The house dust mite continues to pose a threat to asthmatics, and there is no evidence to support a possible reduction in the source of that allergen in the last two decades. In general, the

extreme allergenicity of arthropods and the potential for cross-reactivity, coupled with the already favorable macro-habitat (temperature, humidity, density of homan populations) and the ever-improving micro-habitat (such as moisture in the home, synthetic fibers, reduced ventilation) will certainly continue to play a role in the increasing prevalence of asthma among tropical inhabitants.

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BIOGRAPHICAL SKETCH

Kathleen Carole Barnes was born in Akron, Ohio, October 27, 1960, and spent most of her childhood in Danville, VA. In 1979 she entered James Madison University, Harrisonburg, VA, as a music major, and studied the flute for three years, before transferring to the Medical College of Virginia in Richmond, where she completed her B.S.N. in 1984. She worked for two years at the MCV Hospitals in maternal-child health, before entering the University of Florida, Gainesville, in pursuit of her Ph.D. in biocultural anthropology. During her graduate studies, she worked part-time in maternal-child health nursing at Shands Teaching Hospital, taught a part-time nursing course at the Santa Fe Community College, and functioned as a graduate assistant at the Medical and Veterinary Entomology Research Laboratory, USDA/ARS. During the summer of 1988, Barnes conducted a pilot study on allergy in the Dominican Republic, where she studied Spanish. During her studies in Barbados, she traveled much of the Eastern Caribbean. Her areas of specialization are vector-borne disease, allergy, and Caribbean health issues. For leisure, she enjoys scuba diving, music, and photography. After graduating she will begin a postdoctorate position in the Department of Medicine at Johns Hopkins University, Baltimore.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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This dissertation was submitted to the Graduate Faculty of the Department of Anthropology in the College of Liberal Arts and Sciences and to the Graduate School and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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